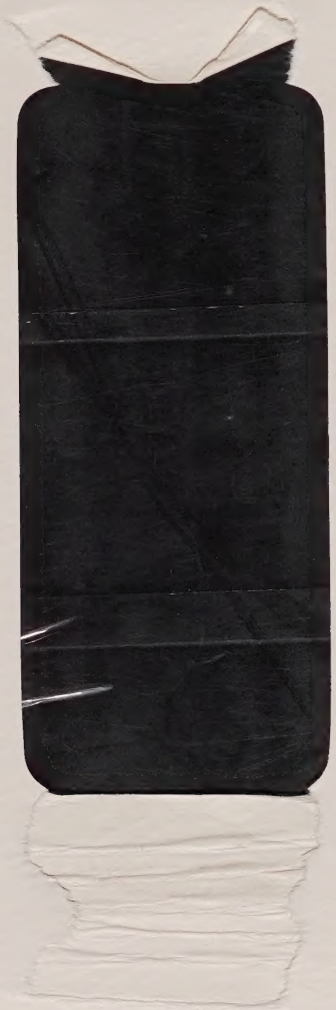
AMP-5A

microwave amplifier

560A SERIES

Model 562AC Serial 1418

ALFRED ELECTRONICS 3176 PORTER DRIVE, PALO ALTO, CALIF.

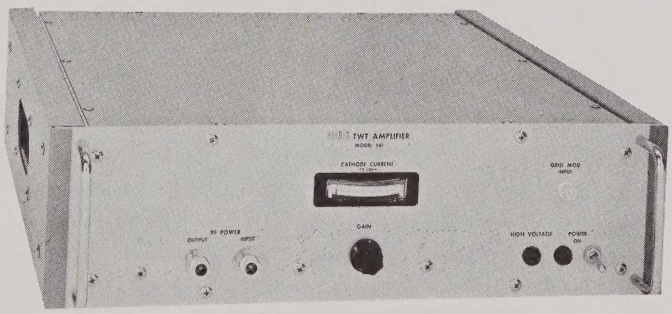


INSTRUCTION MANUAL

microwave amplifier

560A SERIES

Model 562AC Serial 1418



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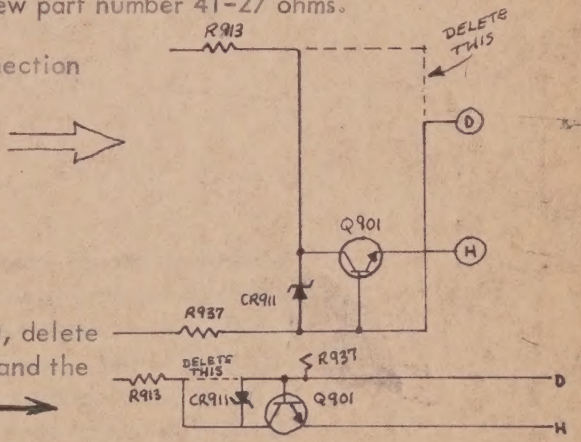
Section 6 SCHEMATICS

Schematics are included in the following order:

9000682C - Low Voltage Power Supplies
900683C - Heater & High Voltage Supplies
900778C - High Voltage Anode Supply (560A & 561A)
900864C - Low Voltage Anode Supply (562A & 563A)
900777D - TWT Amplifier Main Chassis (560A & 561A)
900779D - TWT Amplifier Main Chassis (561A & 562A)

Date	ECO#	Effective Serial's	Revision
10/10/6	13097	251 &up	In Schematic 900777D and Figure 3-2 (page 3-4) and the Parts List (Group 1), make the following changes: R402 46-9.1 K 9.1 K, 2 w, Fixed, Comp., 5% R403 41-27 K 27 K, 1/2 w, Fixed, Comp., 10% R405* factory-selected nominally 3.16 K CR402 81-96 1N793A
8/5/6	12983D	181 &up	In the Parts List (page 5-4) and Figure 3-4 (page 3-6), change the value of C106 from .01 to .022 mf.
10/26/6	13087	181 & up	In the Parts List (group 1 page 5-3) and Schematic 900777D, change R932 from 68 ohms to 39 ohms. The new part number is 41-39 ohms, factory-selected value. Change R933 to 27 ohms with the new part number 41-27 ohms.
10/26/6	13087	181 & up	In the Parts List (group 2 page 5-5) and Schematic 900779D, change R934 to 39 ohms (factory-selected value) with the new part number 41-39 ohms. Change R933 to 27 ohms with the new part number 41-27 ohms.
1/9/67		All	In Figure 3-1, delete the wire connection between pin D of PC 200 and the collector of Q901. 
1/9/67		All	On drawings 900777D and 900779D, delete the wire connection between R913 and the anode of CR911.
8-11-67	12983D	181 & up	In the Parts List (group 2 page 5-4), change Q106 to 2N3645, part no. 81-129. In Figure 3-4, change Q106 to 2N3645.
9-7-67		All	In the List of Traveling-Wave Tubes at the bottom of page 5-6, change from Stewart to MEC tube numbers as follows: Model 560AC V905, MEC M-4268K Model 560AF V905, Warnecke, WR-130 Model 561AC V905, MEC M-4260K Model 562AC V905, MEC M-4278K Model 563AC V905, MEC M-4273K

SECTION 1 — INTRODUCTION

1.1 SPECIFICATIONS

Frequency Range:	Model 560A, 1 - 2 Gc Model 561A, 2 - 4 Gc Model 562A, 4 - 8 Gc Model 563A, 7 - 12.4 Gc
Power Output:	1 watt minimum.
Gain:	Small signal, 30 db minimum. At rated power, 30 db minimum.
RF Impedance:	50 ohms.
RF Connectors:	Type N Female.
Gain Adjustment:	Front panel control provides a 50 db control range.
Gain Variation with Line Voltage Variation:	0.2 db or less at 1 watt output with a line voltage variation of 105 to 125 volts.
Maximum Mismatch for Rated Power Out:	1.5:1
For No Tube Damage:	5 : 1
Modulation:	GRID MOD INPUT connector coupled to ANODE of TWT. With the GAIN control set to no cathode current, a 0 to +10 volt signal turns cathode current of TWT to maximum. With the GAIN control set to maximum cathode current, a 0 to -10 volt signal turns cathode current of TWT off. Input impedance; 10 K Ω.
RF Rise Time:	Models 560A and 561A less than 4 μsec. Models 562A and 563A less than 2 μsec.
Spurious Modulation:	At least 45 db below output signal level.
Time Delay:	Automatic 90 second time delay before application of high voltage.

Metering:	Cathode current by front panel meter.
Power Supply:	All electrode voltages are regulated. Protective relays turn off traveling wave tube power on helix overcurrent.
Power Input:	105 to 125 volts or 210 to 250 volts; 50/60 cycles/second; approximately 250 voltamperes.
Physical:	See Figure 1-1.
Weight:	Less than 43 pounds.

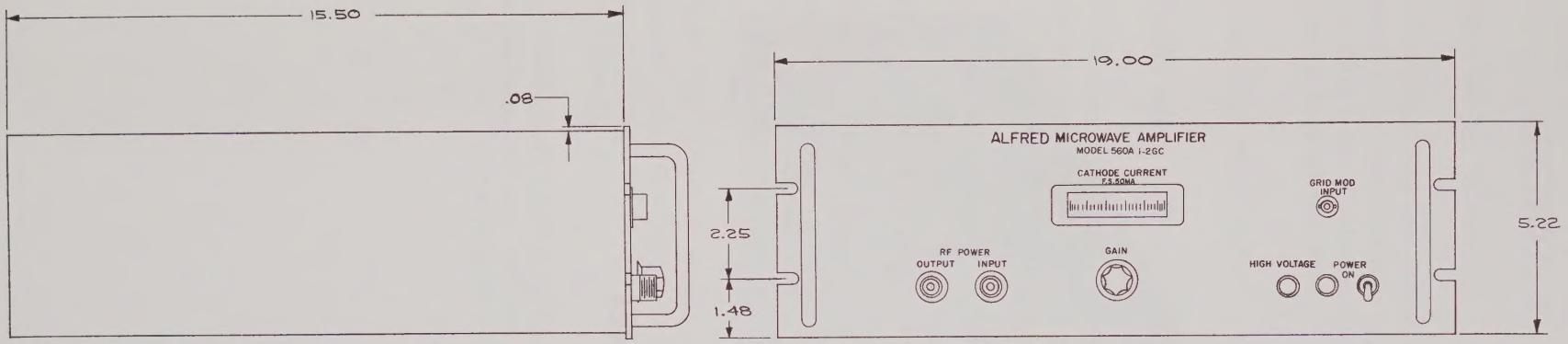
1.2 DESCRIPTION

The ALFRED 560A Series Microwave Amplifiers are amplifiers and modulators of microwave signals in the frequency range of 1 to 12.4 Gc. They are high gain (30 db) instruments utilizing a traveling wave tube powered by low drift, low ripple, precisely regulated transistorized power supplies.

The anode (positive grid) of the traveling wave tube is coupled to the GRID MOD INPUT jack. Modulation of the rf can be accomplished by either a 0 to +10 volt or a 0 to -10 volt signal applied through the connector. The front panel gain control varies the traveling wave tube cathode current over a 50 db range.

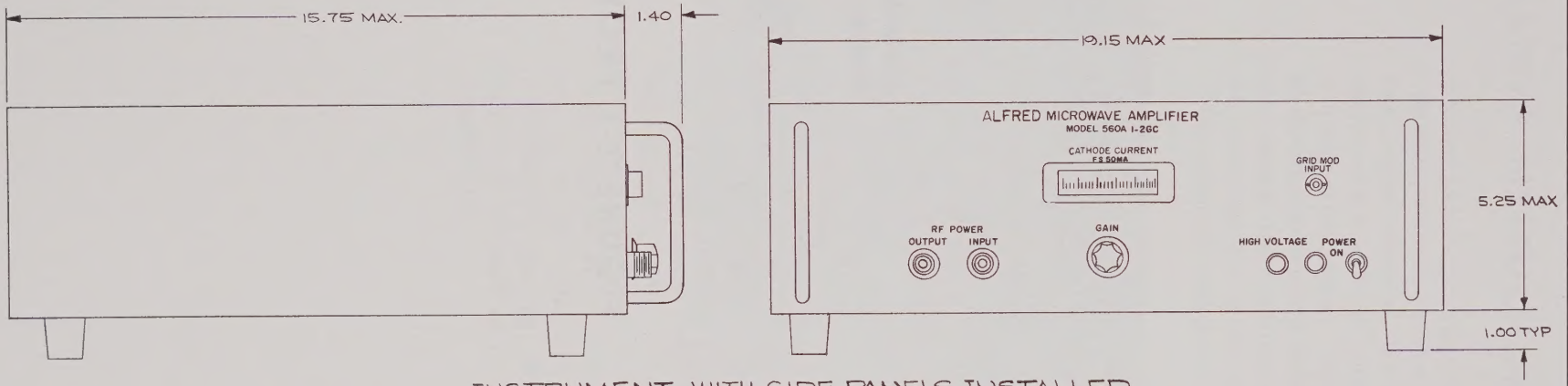
The traveling wave tube does not require rf adjustment, is encapsulated for protection and is easily replaced. A front panel meter monitors cathode current. Protective circuits reduce the likelihood of damage to the tube.

SYM	DESCRIPTION	NO.	DATE	BY



INSTRUMENT WITH SIDE PANELS REMOVED

(FOR RACK MOUNTING)



INSTRUMENT WITH SIDE PANELS INSTALLED

NOTES:

1. THE MODEL 560A SERIES INSTRUMENT MAY BE EITHER BENCH MOUNTED OR RACK MOUNTED.
2. FOR RACK MOUNTING, REMOVE BOTH SIDE PANELS.
3. WEIGHT OF INSTRUMENT IS LESS THAN 43 POUNDS.

FIGURE 1-1

ITEM	REQD	PART NO.	DESCRIPTION
			LIST OF MATERIAL

MATERIAL	DRAWN Dave Presley	DATE 9-2-64	OUTLINE & DIMENSIONAL DATA FOR MODEL 560A SERIES INSTRUMENT
MATERIAL STOCK NO.	ENG Y. Oshima	9-4-64	
FINISH OR TREATMENT	PROD		DIMENSIONS ARE IN INCHES TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½° UNLESS INDICATED OTHERWISE
	SCALE 1:2		

NEXT ASSY	USED ON
	560A SERIES

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

990131C

SHEET 1 OF 1

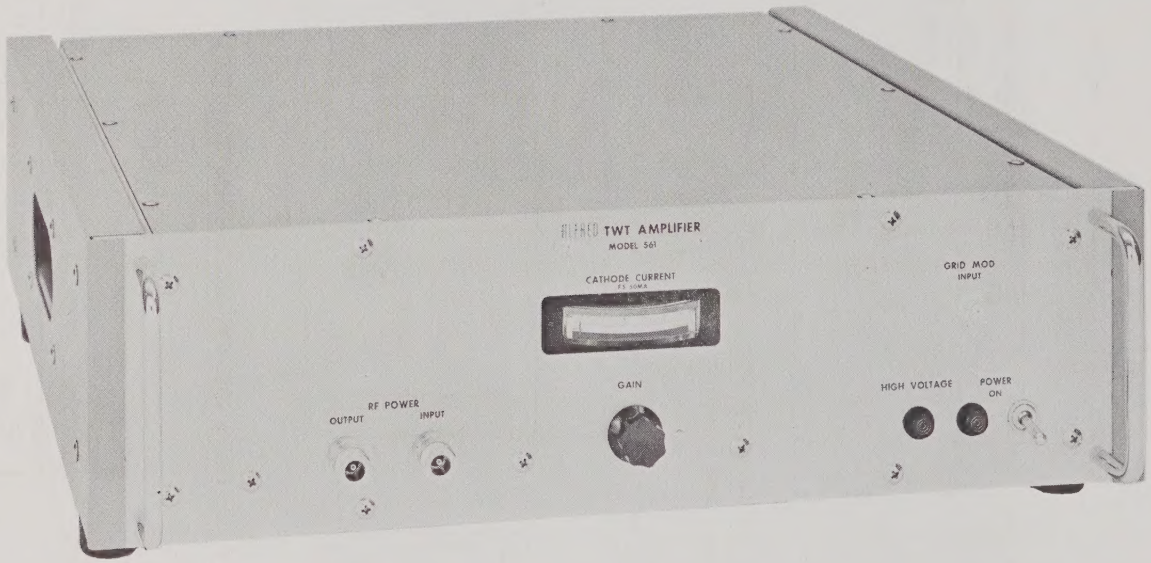


FIGURE 2-1. FRONT PANEL

SECTION 2 — OPERATING INSTRUCTIONS

2.1 FRONT PANEL CONTROLS

GAIN CONTROL: The gain control adjusts the cathode current and hence the gain of the traveling wave tube. Cathode current is monitored by the front panel meter.

2.2 OPERATING PROCEDURES

Turn POWER switch to ON.

NOTE: Time delay relays used in the Model 560A Series delay high voltage turn-on for approximately 90 seconds after the power is turned on. This is to allow a brief warm-up period for the traveling wave tube filament. If the ac power is off for only an instant, the normal 90 second delay will occur before the high voltage returns.

After the high voltage appears the unit is ready for operation. Rf power and modulation voltages can be applied to the RF POWER INPUT and GRID MOD INPUT connectors respectively.

The Model 560A Series Microwave Amplifiers are designed to accept a 0 to -10 volt modulation signal although a 0 to +10 volt signal will also modulate the rf.

With the GAIN control turned up (clockwise) an input signal between 0 and -10 volts will modulate the rf. With the GAIN control turned down (counterclockwise) an input signal between 0 and +10 volts will modulate the rf. To obtain 100% modulation of the rf, the GAIN control and possibly the modulation input signals amplitude will require adjustment. This can best be accomplished by observing the detected rf signal on an oscilloscope. The conditions for 100% modulation will vary from unit to unit because of variations in the operating voltages of the traveling wave tubes.

Any applied modulation voltage which is less than the voltage required for 100% modulation will only partially modulate the rf. Any applied modulation voltage which is greater than the voltage required for 100% modulation will overdrive the preamplifier. However, no damage will occur because the input is adequately protected.

2.3 POWER REQUIREMENTS

The unit is normally connected at the factory for operation at 105 to 125 volts and 50 to 60 cycles ac (115 volts nominal). However, provisions are made for easy conversion to operation at 210 to 250 volts, 50 to 60 cycles ac (230 volts nominal). See Figure 4-2. With the bottom cover removed locate the power switch labeled 115 VAC. By removing and reversing this plate, the switch can be moved to the left. Replace the plate with 230 VAC showing. Replace the 3 ampere main fuse (in back of instrument) with a 1.5 ampere fuse.

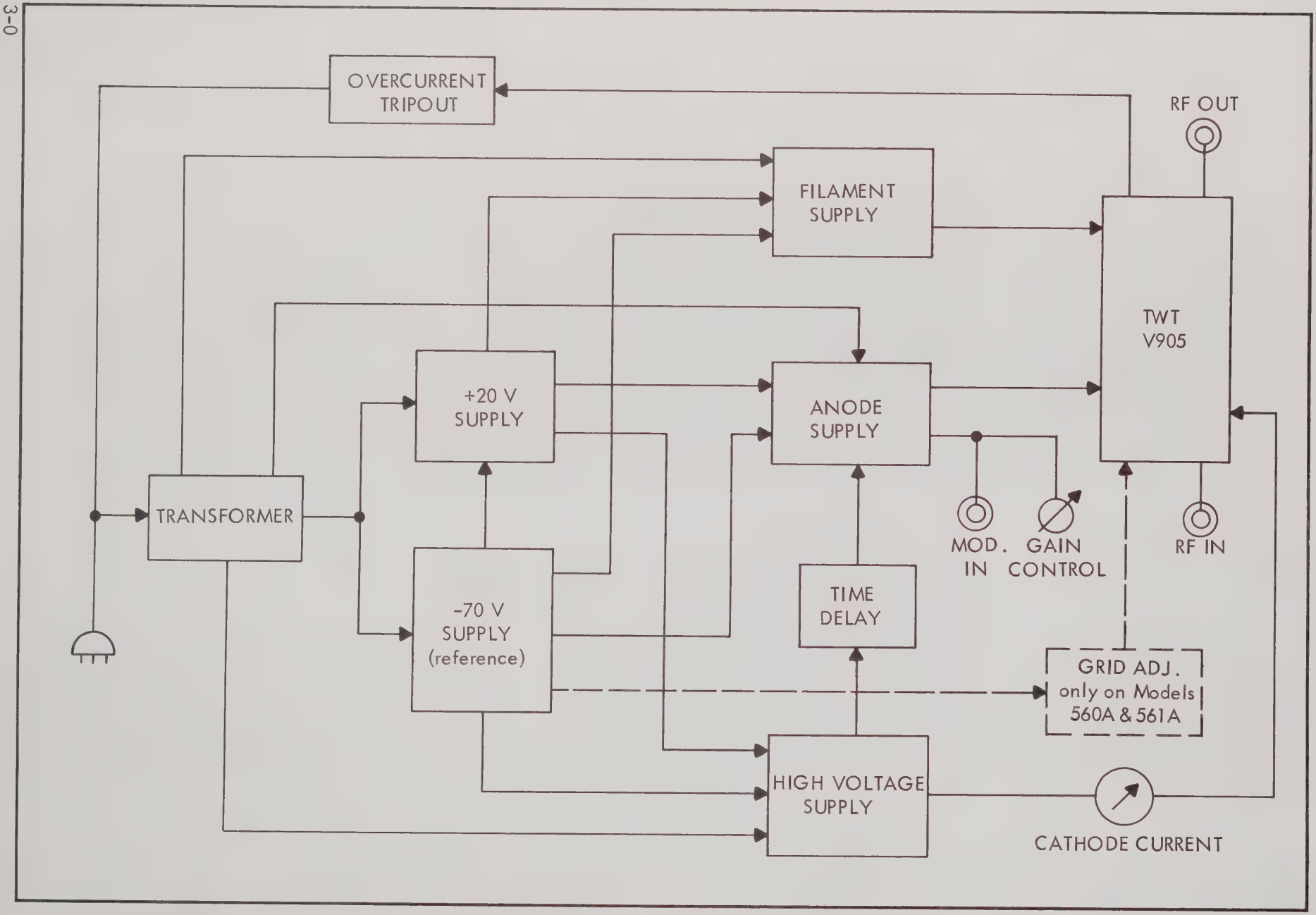


FIGURE 3-0. BLOCK DIAGRAM OF MODEL 560A SERIES TWT AMPLIFIER

SECTION 3— CIRCUIT DESCRIPTION

3.1 THE TRAVELING WAVE TUBE

The traveling wave tube consists of an electron gun, a slow wave structure (helix) and a collector at the far end of the slow wave structure. The electron gun produces a beam of electrons which travel along the axis of the helix to the collector. The forces produced by a longitudinal magnetic field, which surrounds the tube, restricts beam travel axially along the tube, just inside the helix. The rf signal to be amplified is coupled to the helix, at the electron gun end, and travels down the metallic path of the helix in the same direction as the beam. The velocity of the electron beam is determined by the potential difference between the cathode and the helix, and this voltage difference is adjusted so that the beam velocity down the tube is just a little faster than the rf wave. The alternating field produced by the rf signal causes the electrons to bunch. As the rf field advances towards the collector, it encounters more and more bunches of electrons. Amplification occurs when these groups of electrons give up energy to the rf signal as it travels down the helix. The amplified waves are then coupled off the helix through a low impedance device. Reflections are prevented by an attenuator; a lossy helix placed externally between input and output.

A more complete description of traveling wave tube theory and operation is presented in the "Engineering Notes" at the end of this manual.

3.2 POWER SUPPLIES

See Block Diagram Figure 3-0.

The unit has four independent power supplies; the +20 volt supply, the ANODE supply, the HEATER supply, and the HIGH VOLTAGE supply, all of which use a fifth supply, the -70 volt supply as a reference. The -70 volt supply, in turn, uses a temperature compensated zener diode as its reference.

3.2.1 THE +20 AND THE -70 VOLT POWER SUPPLIES (LOW VOLTAGE)

See Figure 3-1.

These two supplies consist essentially of two differential amplifiers; Q209-Q210 and Q211-Q212 for the -70 volt supply and Q203-Q204 and Q205-Q206 for the +20 volt supply. CR203 is a temperature compensated 6.2 volt zener diode and is contained on one side of the first differential amplifier of the -70 volt supply. The differential amplifiers, of each supply, feed the driver stage of power transistors Q202 (+20 volt) and Q208 (-70 volt) which are used as series regulators. The -70 volt supply can be adjusted by means of R221. A zener diode is used to start and to protect the -70 volt supply while a transistor circuit is used to start and protect the +20 volt supply.

3.2.2 THE HEATER AND HIGH VOLTAGE SUPPLIES

See Figure 3-2.

The HEATER supply for the traveling wave tube is referenced to both the +20 and -70 volt supplies, making it independent of both line and load. This 6.3 volt supply can deliver up to 2 1/2 amperes to the filament with only a nominal change in ripple or regulation.

The HIGH VOLTAGE supply (Helix and Collector) is capable of delivering 50 ma at 2.7 kv. The magnitude of this voltage is set by feedback resistors R926 through R932 and potentiometer R309. A one microfarad capacitor is used in the output of this supply to prevent fluctuations due to changes in current or load. The HELIX CURRENT TRIP-OUT circuit is essentially a

summing amplifier and operates such that if more current is taken from the base of Q401 than that specified, the succeeding amplifiers saturate causing relays K901 and K904 to trip, opening the line to the power transformers. (See Table 4-1).

3.2.3 THE ANODE SUPPLY

See Figures 3-3 and 3-4.

The ANODE supply is the most critical of all the supplies in the unit. Its function is to supply a regulated and stable voltage to the anode of the traveling wave tube and yet it must have a very fast response to meet the modulation specifications.

The anode of the traveling wave tube is a positive, low current electrode which controls cathode current and hence the gain and power output of the tube. The anode is the element that is used for the purpose of modulation. The modulation input jack is coupled to the preamplifier for the anode supply. When a modulation voltage is applied, the preamplifier drives the entire anode supply. The anode supply is adjustable by the ANODE MAX potentiometer R111 for the 560A and 561A or R119 for the 562A and 563A.

3.2.3.1 HIGH VOLTAGE ANODE SUPPLY (560A/561A). In the 560A/561A Series, High Voltage Anode Supply PC Board PC100 drives regulator amplifier tube V906 to control regulator tube V904. V904, in series with the anode supply output from PC400-10, controls the voltage applied to the TWT Anode (Grid 2) which is connected to the V904 cathode via CR914. V904 thus provides a variable voltage drop, controlled by PC100, between the PC400-10 output and the TWT. CR914 (Fig. 3-2), supplies an additional fixed drop of 56 V, with the result that the output at the TWT is controlled between 0 and + 650 V.

On PC100 (Fig. 3-3), Q103 and Q104 constitute the differential input stage of the anode supply voltage control amplifier. Three separate control inputs are supplied to Q103: (1) the feedback signal proportional to instantaneous anode voltage, tapped from the TWT anode via C915/R925 and applied to PC100-E; (2) a variable offset signal tapped from the panel GAIN Control R923 and/or a modulation input from GRID MOD INPUT jack J910, amplified by Q101; (3) a disabling signal from K902, supplied whenever high voltage is turned off by that relay, coupled to Q103 by Q102.

A negative-going signal level change at the base of Q103 causes it to conduct more heavily, driving the differential stage to reduce the conduction of Q104. Q104 controls the current through output stage Q105 which provides voltage gain. A negative-going change at the base of Q103 thus decreases the current through load resistor R120 and increases the negative voltage applied to the grid of V906 via J100-Y. This drop in grid voltage reduces the conduction of V906, thereby decreasing the drop across its load resistor R910. (R910 is connected to the regulated anode supply output voltage line PC400-7 by K905 after initial turn-on.) This drop across R910 determines the grid-to-cathode bias of V904, in this case biasing V904 to heavier conduction so that its plate-to-cathode drop is decreased, thus raising the anode voltage. Maximum output voltage at the cathode of V904 is > 706 V. This is dropped 56 V by CR914 to a maximum of > 650 V at TB901-3 to drive the TWT anode.

Conversely, a positive-going change at the base of Q103 produces a decrease in anode voltage by the reverse of the process described above. The dynamic range of the Q103/Q104 stage is such that the base of Q103 operates at or below ground level, with a ground-level signal turning "off" the anode supply output by biasing V904 to the point where its cathode is at < + 56 V, which is translated to < 0 V at the TWT anode (TB903-3) by CR914.

Turning the GAIN control R923 CW to increase gain causes an increasingly positive voltage to

be applied to J100-B, thereby tending to decrease the forward bias of Q101 and reduce its conduction. This decreases the current through R106 and thus produces a negative-going change at the base of Q 103, as required to raise the anode voltage as described above. The GAIN control and GRID MOD INPUT signals are summed at the base of Q101, allowing use of a modulation signal of either polarity by proper adjustment of the GAIN control to provide suitable offset. Thus, with the GAIN control fully CW (+20 V), Q101 is biased almost to cutoff and a 0 to -10 V MOD signal can be applied to turn it on and off for anode voltage modulation. With the GAIN control fully CCW (0 V), Q101 is biased to saturation, and a 0 to +10 V signal can be applied to turn it off and on for anode voltage modulation. The drop across R103 and the filtering action of C101 stabilizes the steady bias voltage from the GAIN control and provides isolation between the dc signal from the GAIN control and the pulsed MOD signal.

The feedback signal to J100-E tracks the instantaneous anode voltage to provide negative feedback to the base of Q103 via R111. R111 is used to set the feedback level at the maximum output point when the GAIN control is fully CW.

K902, which enables high voltage power, supplies -70 V to the base of Q102 whenever K902 is de-energized to turn off high voltage power. This -70 V input causes Q102 to saturate, thereby raising the base of Q103 to ground level, the point at which 0 V anode supply output is obtained.

3.2.3.2 LOW VOLTAGE ANODE SUPPLY (562A/563A). In the 562A/563A Series, Low Voltage Anode Supply PC Board PC100 provides output of 0 to +60 V to drive the TWT anode. Q103 and Q104 constitute a regulator circuit for the +80 V supply output from PC400-8. Q103 senses the output level at the junction between R108 and R111, and controls the conduction of Q104 so that R113 shunts the supply output by the proper amount to achieve a +80 V output level.

Q106 is the input stage of the anode supply voltage control amplifier. Three separate control inputs are supplied to Q106: (1) the feedback signal proportional to instantaneous anode voltage, tapped from the output at the collector of Q108 and impedance-converted by emitter follower Q105; (2) a variable offset signal tapped from the panel GAIN control R923 and/or a modulation input from GRID MOD INPUT jack J910, amplified by Q101; (3) a disabling signal from K902, supplied whenever high voltage is turned off by that relay, coupled to Q106 by Q102.

A negative-going signal change at the base of Q106 causes it to conduct more strongly, thereby increasing the current through R123 so that the base voltage of Q107 becomes less negative. This causes Q107 to conduct more heavily, driving the Q107/Q108 differential stage to produce a decrease in the conduction of Q108. The resultant decrease in current through R130 produces an increase in the voltage at the base of Q109. This increase drives Q109 to heavier conduction and raises the anode supply output voltage at J100-V. Conversely, a positive-going signal change at the base of Q106 produces a decrease in the anode supply output voltage.

Turning the GAIN control R923 CW to increase gain causes an increasingly positive voltage to be applied to J100-C, thereby tending to decrease the forward bias of Q101 and reduce its conduction. This decreases the current through R107 and thus produces a negative-going change at the base of Q106, as required to raise the anode voltage as described above. The GAIN control and GRID MOD INPUT signals are summed at the base of Q101, allowing use of a modulation signal of either polarity by proper adjustment of the GAIN control to provide suitable offset. Thus, with the GAIN control fully CW (+20 V), Q101 is biased almost to cutoff and a 0 to -10 V

MOD signal can be applied to turn it on and off for anode voltage modulation. With the GAIN control fully CCW (0 V), Q101 is biased to saturation and a 0 to +10 V signal can be applied to turn it off and on for anode voltage modulation. The drop across R105 and the filtering action of C101 stabilizes the steady bias voltage from the GAIN control and provides isolation between the dc signal from the GAIN control and the pulsed MOD signal.

The feedback signal from Q105 tracks the instantaneous anode voltage to provide negative feedback to the base of Q106 via R119. R119 is used to set the feedback level at the maximum output point when the GAIN control is fully CW.

K902, which enables high voltage power, supplies -70 V to the base of Q102 whenever, K902 is de-energized to turn off high voltage power. This -70 V input causes Q102 to saturate, thereby raising the base of Q103 to ground level, the point at which 0V anode supply output is obtained.

Table 3-1. Functions of Interlock Relays and Switches in the 560A Series

Component	Energized by	De-Energized by	Function
K901	T903, when power is connected between points Y and Y_1 (which occurs when K904 is energized due to a helix overcurrent condition). Once energized, K901 is self-latching by means of power supplied from #16-17 of T902.	Turning POWER switch off and then on, to break self-latching circuit, after helix overcurrent trouble has been corrected, so that K904 no longer completes the power circuit between points Y and Y_1.	A power control interlock relay which applies 115 V power for T901 to one contact of K902, thereby allowing K902 to energize high voltage transformer T901 except when a helix overcurrent condition exists.
K902	K906 and K903, when K906 is de-energized and K903 is energized. K906 is de-energized when a heater over-voltage condition does not exist, and K903 is energized (also by a circuit through de-energized K906) after a 90-second delay whenever power is applied to the instrument. Once energized, K902 is self-latching as long as K906 remains de-energized.	Energization of K906 due to a heater over-voltage condition, or by inoperation of time delay relay K903.	Controls primary 115 V power input to high voltage transformer T901, enabling high voltage output only when energized. When de-energized, applies -70 V to J100-Z (560A/561A) or J100-J (562A/563A) to disable the anode supply by biasing Q102 to heavy conduction, thereby dropping the anode supply output from its normal + level to ground level.
K903	K902 and K906, when both de-energized, supply power to the K903 time delay coil. The K903 contact is closed 90 seconds later.	When the K903 contact is closed after the 90-second time delay, it energizes K902, and the form C contact on K902 then de-energizes K903 at the same time it self-latches K902.	Delays turn-on of high voltage power circuits driven by T901 until the low voltage power circuits and the TWT heater driven by T902 have been allowed a 90-second warmup interval.
K904	Q402, when driven to saturation by the cutoff of Q401 when excess current is taken from the base circuit of Q401 by a helix overcurrent condition.	Cutoff of Q402 when Q401 is turned on under operating conditions where helix current is within the permissible range so that the drop across R405 is not excessive.	Turns off high voltage power for protection of the TWT against helix overcurrent, by energizing T903 which, in turn, energizes K901 when an overcurrent condition occurs, causing K901 to remove power from terminal 1 of T901.

Table 3-1. Functions of Interlock Relays and Switches in the 560A Series (cont)

Component	Energized by	De-Energized by	Function
K905	PC400 Screen Supplies and C409 (560A/561A); T902 and C914 (562A/563A), when the capacitor has charged up to relay-operating voltage after power turn-on.	Turn-off of power to instrument.	Provides a time delay in the turn-on of the Anode Supply by opening the + voltage supply line to regulator V906 (560A/561A) or grounding the +80 V supply line to J100-Z (562A/563A).
K906	Saturation of heater over-voltage amplifier Q904 when excessive heater voltage appears across R920.	Cutoff of Q904 when heater over-voltage condition is eliminated.	Through one set of contacts, breaks the heater supply circuit to J300-T to prevent over-voltage damage to the TWT heater. Through another set of contacts, de-energizes K902 to remove high voltage power (since K902, in turn, de-energizes T901).
S903 High Voltage Interlock Switch	Closed by proper installation of top cover panel.	Opened by removing top cover panel.	When closed, completes 115 V primary power circuit to T901 via K901 and K902. When opened, removes power from T901 to eliminate high voltage exposure danger.
S904 Air Flow Interlock Switch	Closed by exposure to suitable air flow pressure from fan.	Opens when insufficient air circulation exists.	When closed, completes 115 V primary power circuit to T901 via K901, K902, and S903. When opened, removes power from T901 to shut off the TWT tube in the absence of sufficient cooling air circulation.

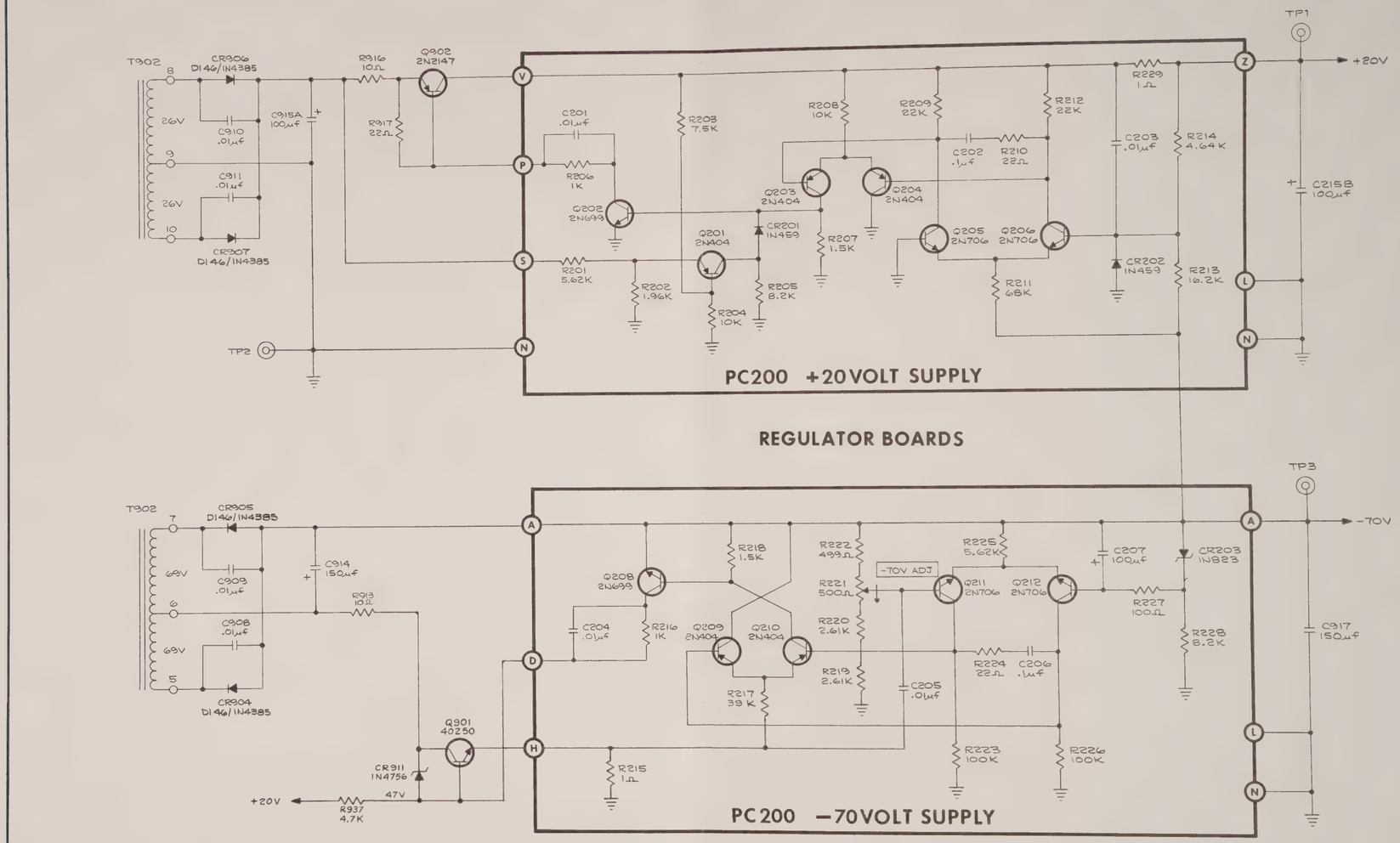


FIGURE 3-1. +20V AND -70V SUPPLIES

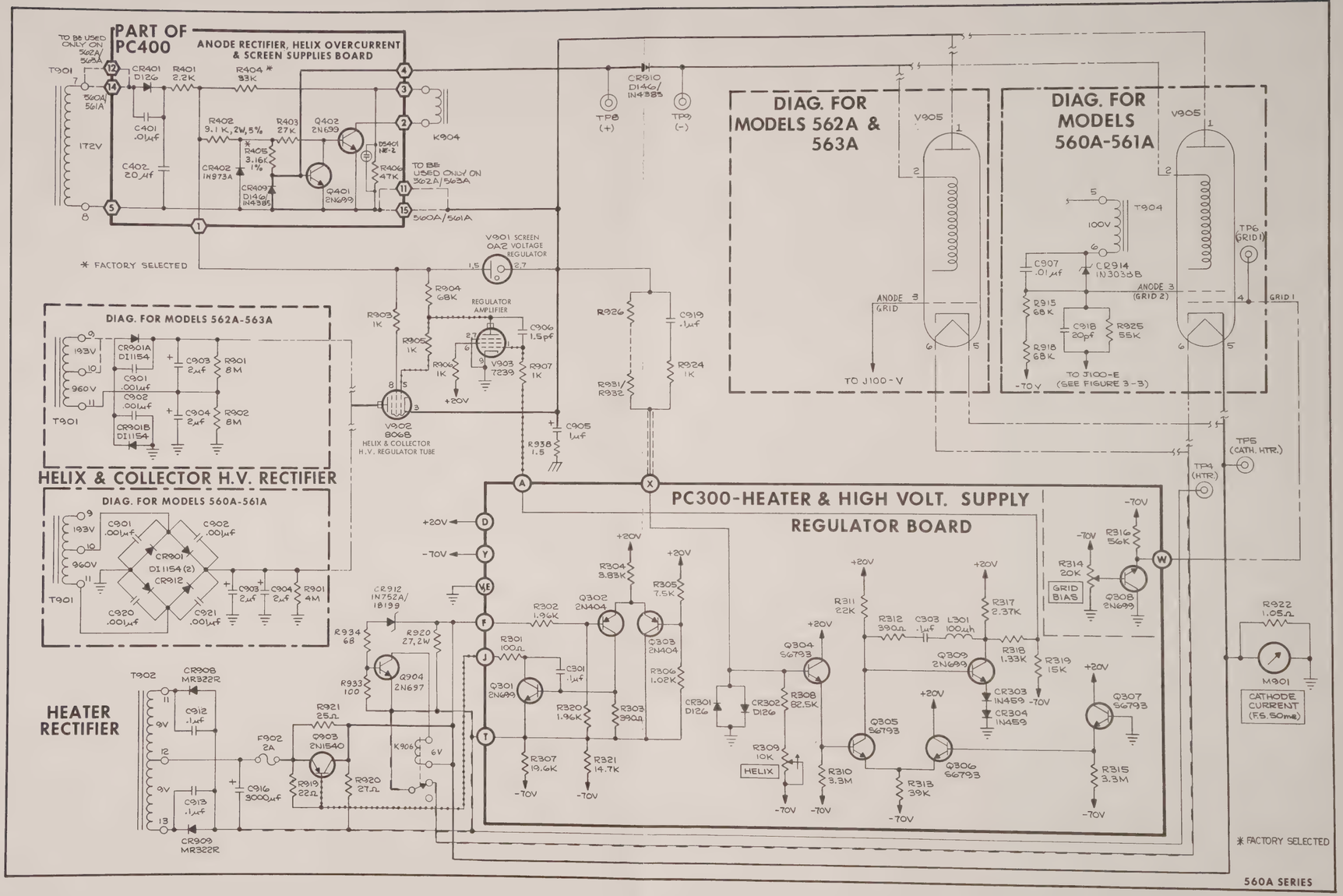
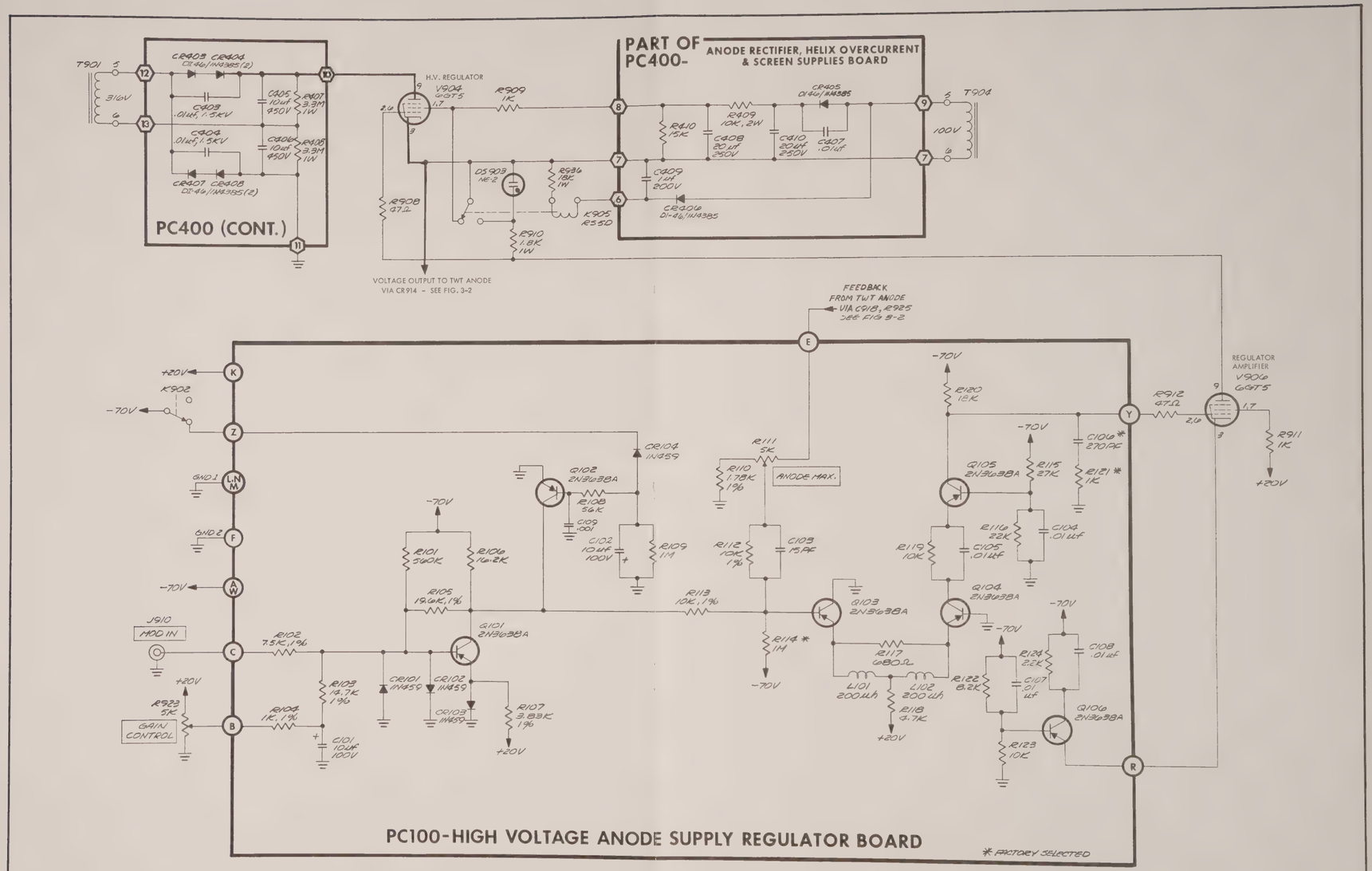


FIGURE 3-2. HEATER AND HIGH VOLTAGE SUPPLIES


PC400 (CONT.)
PART OF PC400-
ANODE RECTIFIER, HELIX OVERCURRENT & SCREEN SUPPLIES BOARD
H.V. REGULATOR
VOLTAGE OUTPUT TO TWT ANODE VIA CR914 - SEE FIG. 3-2
FEEDBACK FROM TWT ANODE VIA C918, R925 SEE FIG 3-2
REGULATOR AMPLIFIER V906 6GT5
PC100-HIGH VOLTAGE ANODE SUPPLY REGULATOR BOARD
* FACTORY SELECTED

560A/561A SERIES

FIGURE 3-3. 560A/561A (HIGH VOLTAGE) ANODE SUPPLY

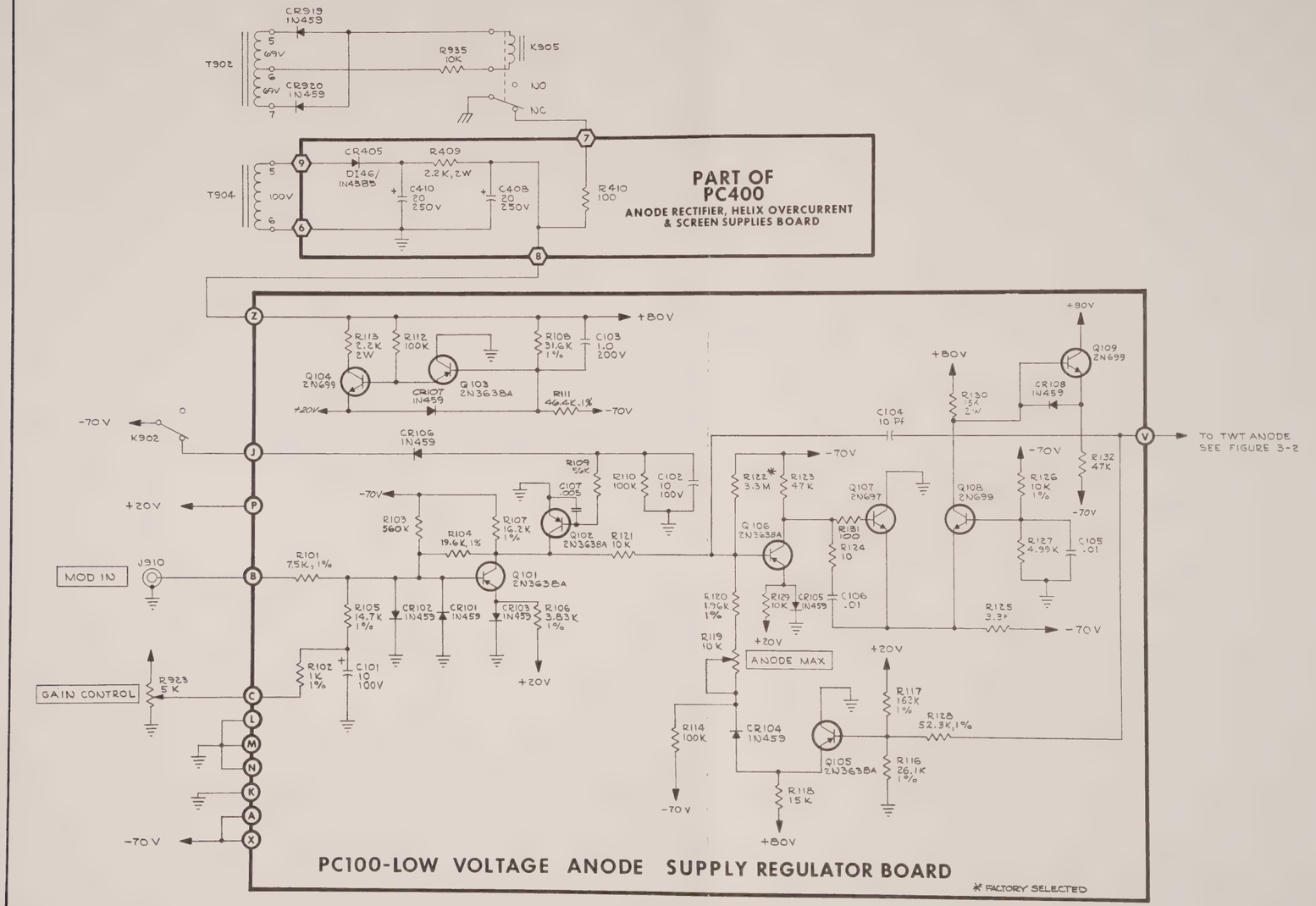


FIGURE 3-4. 562A/563A (LOW VOLTAGE) ANODE SUPPLY

SECTION 4 — MAINTENANCE

CAUTION: High voltages exist in this instrument. Observe caution when calibrating or performing maintenance on the unit. When the top cover plate is removed, the high voltage interlock turns the high voltage off.

4.1 TEST POINTS

See Figure 4-1.

TP2, CHASSIS GROUND

TP2 to TP1, +20 VOLTS (low voltage supply; 20 volts, ± 0.6 volts).

TP2 to TP3, -70 VOLTS (low voltage supply; -70 volts, ± 0.5 volts).

TP5 to TP6, GRID VOLTAGE. (See tube specification in envelope at rear of manual.)

TP5 to TP4, TWT HEATER VOLTAGE. (6.0 volts to 6.6 volts.)

TP7 to TP5, TWT ANODE VOLTAGE. (See envelope.)

TP8 to TP9, HELIX CURRENT. (See envelope.)

TP5 to TP2, TWT CATHODE VOLTAGE. (See envelope.)

4.2 TROUBLE SHOOTING

NOTE: Before attempting to trouble shoot the unit make sure that an apparent trouble is actually due to a malfunction within the instrument and not to improper usage.

CAUTION: Disconnect TWT before all dc checkout.

4.2.1 GENERAL

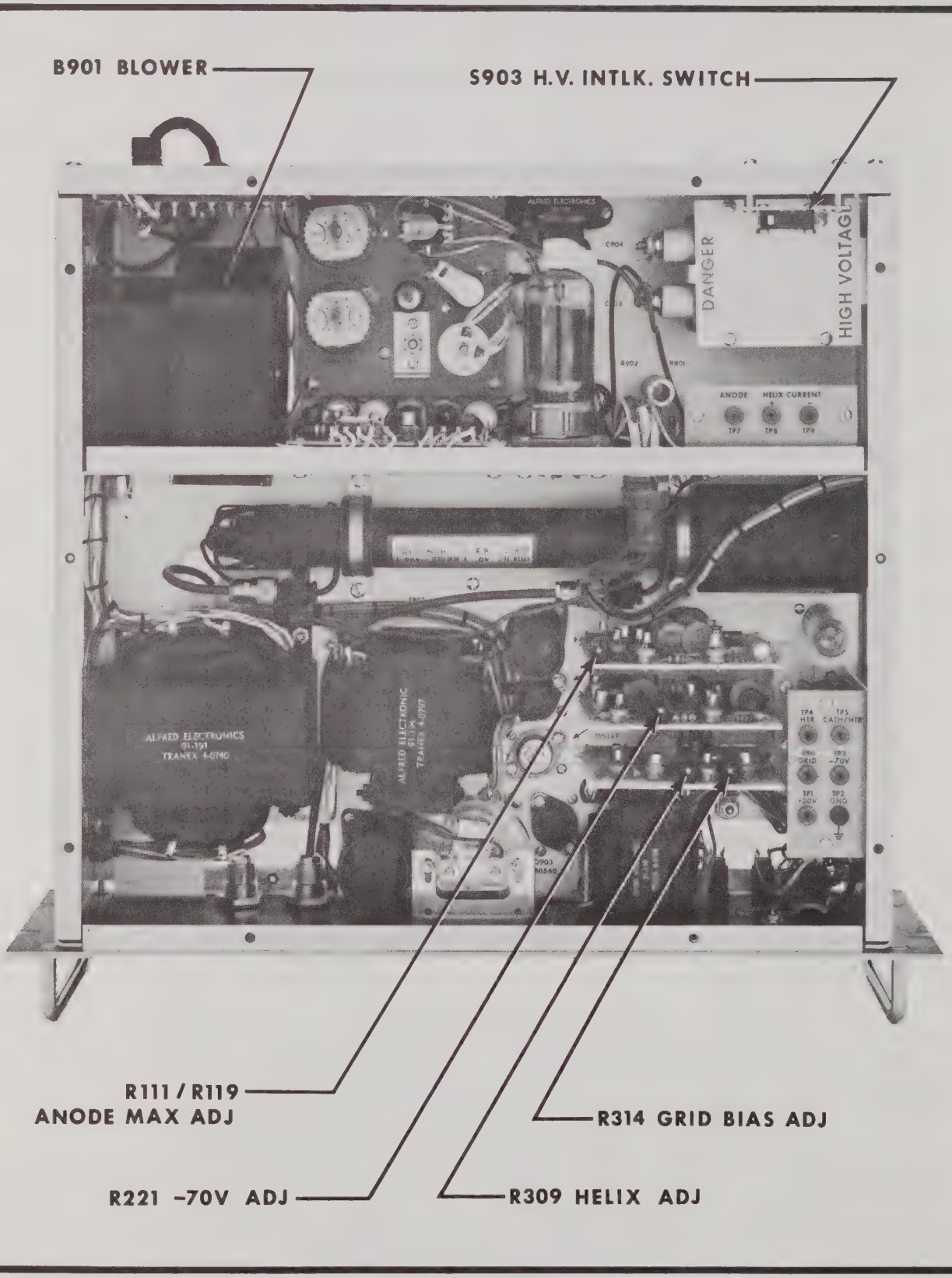
1. Check for and remove all magnetic sources within approximately 12" of the unit.
2. Check all fuses. Replace with type 3AB, 250 volt and current value specified.
3. If power can be applied without blowing fuses, check all power supplies; +20, -70, anode, heater and high voltage.

4.2.2 POWER FUSE BLOWS

1. Check power line for shorts.
2. Measure output impedance of the +20 and -70 volt supplies. The value should be greater than 100 ohms for each supply. If not, trouble shoot the low voltage PC board.
3. Check low voltage rectifiers with an ohmmeter.
4. Check for shorts across transformer T902.

4.2.3 HIGH VOLTAGE FUSE BLOWS

1. Remove thermal relay K903.
2. Measure LOW VOLTAGE supplies (dc check).
3. Check high voltage rectifiers.
4. Check the impedance of the high voltage supply for shorts by placing an ohmmeter across the supply output.
5. Check the impedance of the high voltage and anode screen supplies for shorts.
6. Check for burned-out resistors on the high voltage PC board (PC300).
7. Remove high voltage tubes V902 and V903 and check the anode voltage. Replace the high voltage tubes.



TOP VIEW

FIGURE 4-1

4.2.4 POWER LIGHT ON WITH HIGH VOLTAGE LIGHT ON FOR ONLY AN INSTANT

The sequence of events leading to this problem is power light is on, high voltage light comes on 90 seconds later and the overcurrent relay instantaneously trips out causing the high voltage light to go out.

1. Check for MAGNETIC SOURCES near the unit.

2. Disconnect the traveling wave tube.

3. Check the high voltage. If there is high voltage either the ANODE or the HELIX voltages may not be regulating causing the supply to assume the voltage of the raw supply. This indicates an open loop condition in the high voltage supply. Check for disconnected wires to the control grid and check to see if the feedback resistors are intact.

4. If there isn't any high voltage, see if control tube V903 is conducting heavily by checking the grid voltage. The value should be approximately -1.5 volts. If the tube is conducting heavily, check the high voltage PC board.

5. If the high voltage and anode regulate simultaneously, check the TIME DELAY circuit and the relay contacts that feed the time delay circuit. (Be sure the time delay circuit is initially activated.)

4.2.5 NO RF WITH HIGH VOLTAGE ON AND POWER ON

CAUTION: Make sure there is at least 1 mw of power supplied to the RF INPUT.

1. Check for cathode current.

2. Check the traveling wave tube power connections.

3. If there isn't any cathode current remove all modulation inputs.

4. With the modulation voltage disconnected rotate the GAIN control from full on to full off. If the GAIN control has little or no effect, as seen on the meter, remove the high voltage tubes V902 and V903 and check the ANODE voltage. If it does not check out, replace V902 and V903.

5. Check the ANODE feedback resistors R925 and R933.

6. Check GAIN control potentiometer R923.

7. Check screen supplies.

8. Check pins on tubes (bent, broken, etc.)

9. Check raw supply anode voltage.

10. Check TWT filament, TWT filament heater voltage and heater supply fuse F902.

11. Check anode PC board (PC100) for burned out components.

4.2.6 NO MODULATION

1. Check the preamplifier circuitry, the wiring to the preamplifier circuit and the modulation input to the PC board (PC100).

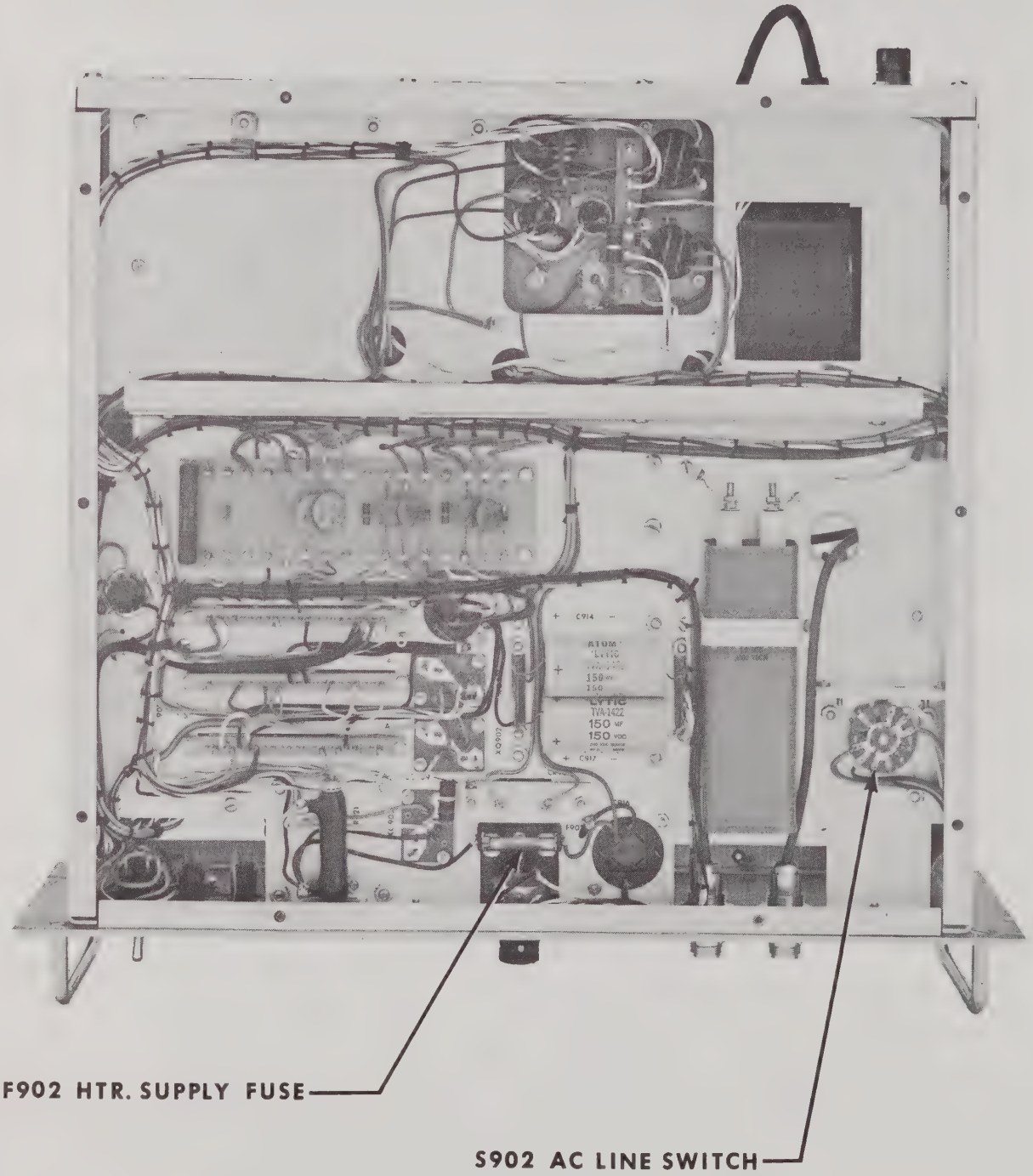
4.2.7 POWER LIGHT ON BUT NO HIGH VOLTAGE AFTER 90 SECONDS

1. Check thermal relay K903.

2. Check the high voltage interlock, S903.

4.3 INTERNAL ADJUSTMENTS

See Figure 4-1.



BOTTOM VIEW

FIGURE 4-2

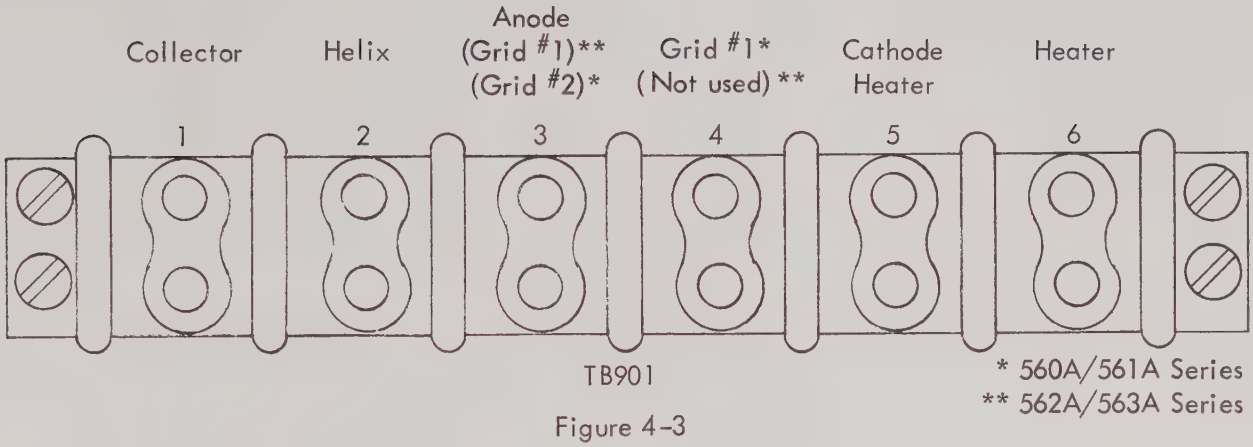


Figure 4-3

There are four internal potentiometers in the unit; the -70 volt adjust R221 (low voltage), the HELIX adjust, R309 (high voltage), the ANODE MAX adjust, R111/R119) and the GRID BIAS adjust R314 (grid).

1. The -70 volt adjust is factory set and should not require readjustment.

2. If there is insufficient rf gain across the band, adjust the HELIX adjust (R309) during sweep mode for optimum power with the GAIN control full on.

3. If there is insufficient power output or cathode current, adjust the ANODE MAX adjust R111 /R119) with GAIN control full on.

CAUTION: The helix current must be monitored. The current must not exceed rated helix current (8 ma for the 1 to 4 Gc frequency range tubes and 4 ma for the 4 to 12.4 Gc frequency range tubes).

4. The GRID BIAS adjust R314, is only operative for the 1 to 2 and 2 to 4 Gc tubes. It adjusts the focusing of Grid #2 but is factory set and should not require adjusting.

4.4 TRAVELING WAVE TUBE REPLACEMENT

To replace the traveling wave tube remove the top and bottom cover plates.

1. Disconnect P913 from J913. See Figure 4-1. On units with serial numbers 61 and up, J913 has been replaced by TB901. Remove the connections from TB901.

2. Disconnect the rf connections from the tube to the unit.

   NOTE: Sylvania tubes come supplied with their own rf input and output cables and connectors. These cables must be used with the tube with which they are supplied. Drop the front panel and remove the cables attached to the unit and replace with those supplied.

3. Remove the four bolts securing the traveling wave tube to the chassis.

4. Remove the tube.

5. Secure new tube to chassis.

   NOTE: If the new tube comes supplied with a Winchester connector, remove the connector, replace with terminal lugs and attach to TB901 per Figure 4-3.

CAUTION: Be sure proper tube to terminal connections are made on the terminal board (TB901).

6. After the tube is installed check the ANODE (Grid #1), HELIX and Grid #2 voltages per the data sheet supplied with the tube. If required, adjust the ANODE voltage R111 for the 560A and 561A or R119 for the 562A and 563A (with front panel GAIN control full on) HELIX voltage R309 and if required Grid #2, R314 to the required voltages.

SECTION 5 — PARTS LIST

GROUP 1

PARTS COMMON TO THE MODEL 560AC, 560AF AND 561AC

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		CAPACITORS
C101	13-33	10 mf, Fixed, Elect., 100 v
C102	13-33	10 mf, Fixed, Elect., 100 v
C103	11-6	15 pf, Fixed, Mica, 5%
C104	12-3	.01 mf, Fixed, Cer., 1000 v
C105	12-3	.01 mf, Fixed, Cer., 1000 v
C106 *	12-27	270 pf, Fixed, Cer., 1000 v
C107	12-3	.01 mf, Fixed, Cer., 1000 v
C108	12-3	.01 mf, Fixed, Cer., 1000 v
C109	12-13	.005 mf, Fixed, Cer., 500 v
C201	12-3	.01 mf, Fixed, Cer., 1000 v
C202	12-34	.1 mf, Fixed, Cer., 100 v
C203	12-3	.01 mf, Fixed, Cer., 1000 v
C204	12-3	.01 mf, Fixed, Cer., 1000 v
C205	12-3	.01 mf, Fixed, Cer., 1000 v
C206	12-34	.1 mf, Fixed, Cer., 100 v
C207	13-40	100 mf, Fixed, Elect., 10 v
C301	12-34	.1 mf, Fixed, Cer., 100 v
C302		Not used
C303	12-34	.1 mf, Fixed, Cer., 100 v
C401	12-3	.01 mf, Fixed, Cer., 1000 v
C402	13-21	20 mf, Fixed, Elect., 250 v
C403	12-3	.01 mf, Fixed, Cer., 1000 v
C404	12-3	.01 mf, Fixed, Cer., 1000 v
C405	13-42	10 mf, Fixed, Elect., 450 v
C406	13-42	10 mf, Fixed, Elect., 450 v
C407	12-3	.01 mf, Fixed, Cer., 1000 v
C408	13-21	20 mf, Fixed, Elect., 250 v
C409	14-13	1 mf, Fixed, Paper, 200 v
C410	13-21	20 mf, Fixed, Elect., 250 v
C901	12-28	.001 mf, Fixed, Cer., 6000 v
C902	12-28	.001 mf, Fixed, Cer., 6000 v
C903	15-18	2 mf, Fixed, Paper, 2000 v
C904	15-18	2 mf, Fixed, Paper, 2000 v
C905	15-20	1 mf, Fixed, Paper 3000 v
C906	12-30	1.5 pf, Fixed, Cer., 6000 v
C907	12-3	.01 mf, Fixed, Cer., 1000 v
C908	12-3	.01 mf, Fixed, Cer., 1000 v
C909	12-3	.01 mf, Fixed, Cer., 1000 v
C910	12-3	.01 mf, Fixed, Cer., 1000 v
C911	12-3	.01 mf, Fixed, Cer., 600 v
C912	12-34	.1 mf, Fixed, Cer., 100 v
C913	12-34	.1 mf, Fixed, Cer., 100 v
C914	13-4	150 mf, Fixed, Elect., 150 v
C915	13-36	100/100 mf, Fixed, Elect., 50 v
C916	13-9	3000 mf, Fixed, Elect., 15 v
C917	13-4	150 mf, Fixed, Elect., 150 v
C918	12-43	20 pf, Fixed, Cer., 1000 v
C919	16-5	.1 mf, Fixed, Plastic, 3000 v
C920	12-28	.001 mf, Fixed, Cer., 6000 v
C921	12-28	.001 mf, Fixed, Cer., 6000 v
		DIODES
CR101	81-41	1N459
CR102	81-41	1N459
CR103	81-41	1N459
CR104	81-41	1N459
CR201	81-41	1N459
CR202	81-41	1N459
CR203	81-75	Zener, 1N823, 6.2 v
CR301	81-20	DI-26 or DI-46
CR302	81-20	DI-26 or DI-46
CR303	81-41	1N459
CR304	81-41	1N459
CR401	81-20	DI-26 or DI-46
CR402	81-96	1N793A
CR403	81-20	DI-26 or DI-46
CR404	81-20	DI-26 or DI-46
CR405	81-20	DI-26 or DI-46
CR406	81-20	DI-26 or DI-46
CR407	81-20	DI-26 or DI-46
CR408	81-20	DI-26 or DI-46
CR409	81-20	DI-26 or DI-46
CR901	81-69	DI-1154
CR902		Not used
CR903		Not used
CR904	81-20	DI-46
CR905	81-20	DI-46
CR906	81-20	DI-46
CR907	81-20	DI-46
CR908	81-93	MR322R
CR909	81-93	MR322R
CR910	81-20	DI-46
CR911	81-125	1N4756
CR912	81-69	DI-1154
CR913	81-77	Zener, 1N752A
CR914	81-31	Zener, 1N3038B (56 v, 1 w)
		TRANSISTORS
Q101	81-114	2N3638
Q102	81-114	2N3638
Q103	81-114	2N3638
Q104	81-114	2N3638
Q105	81-114	2N3638
Q106	81-114	2N3638
Q201	81-51	2N404
Q202	81-72	2N699
Q203	81-51	2N404
Q204	81-51	2N404
Q205	81-73	2N706
Q206	81-73	2N706
Q207		Not used
Q208	81-72	2N699
Q209	81-51	2N404
Q210	81-51	2N404
Q211	81-73	2N706
Q212	81-73	2N706
Q301	81-72	2N699
Q302	81-51	2N404
Q303	81-51	2N404
Q304	81-90	S6793
Q305	81-90	S6793
Q306	81-90	S6793
Q307	81-90	S6793
Q308	81-72	2N699
Q309	81-72	2N699
Q401	81-72	2N699
Q402	81-72	2N699
Q901	81-112	40251
Q902	81-74	2N2147

* Factory Selected

PARTS COMMON TO THE MODEL 560AC, 560AF AND 561AC (CONT)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		TRANSISTORS (CONT)
Q903	81-74	2N1540
Q904	81-71	2N697
		RESISTORS
R101	41-560 K	560 K, 1/2 w, Fixed, Comp., 10%
R102	56-7.5 K	7.5 K, 1/2 w, Fixed, MF, 1%
R103	56-14.7 K	14.7 K, 1/2 w, Fixed, MF, 1%
R104	56-1 K	1 K, 1/2 w, Fixed, MF, 1%
R105	56-19.6 K	19.6 K, 1/2 w, Fixed, MF, 1%
R106	56-16.2 K	16.2 K, 1/2 w, Fixed, MF, 1%
R107	56-3.83 K	3.83 K, 1/2 w, Fixed, MF, 1%
R108	41-56 K	56 K, 1/2 w, Fixed, Comp., 10%
R109	41-1 M	1 M, 1/2 w, Fixed, Comp., 10%
R110	56-1.78 K	1.78 K, 1/2 w, Fixed, MF, 1%
R111	71-94	5 K, Variable, WW, 20 turn
R112	56-10 K	10 K, 1/2 w, Fixed, MF, 1%
R113	56-10 K	10 K, 1/2 w, Fixed, MF, 1%
R114 *	41-1 M	1 M, 1/2 w, Fixed, Comp., 10%
R115	41-27 K	27 K, 1/2 w, Fixed, Comp., 10%
R116	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%
R117	41-680 Ω	680 Ω, 1/2 w, Fixed, Comp., 10%
R118	41-4.7 K	4.7 K, 1/2 w, Fixed, Comp., 10%
R119	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%
R120	41-18 K	18 K, 1/2 w, Fixed, Comp., 10%
R121 *	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R122	41-8.2 K	8.2 K, 1/2 w, Fixed, Comp., 10%
R123	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%
R124	41-2.2 K	2.2 K, 1/2 w, Fixed, Comp., 10%
R201	56-5.62 K	5.62 K, 1/2 w, Fixed, MF, 1%
R202	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%
R203	56-7.50 K	7.50 K, 1/2 w, Fixed, MF, 1%
R204	56-10 K	10 K, 1/2 w, Fixed, MF, 1%
R205	41-8.2 K	8.2 K, 1/2 w, Fixed, Comp., 10%
R206	42-1 K	1 K, 1 w, Fixed, Comp., 10%
R207	41-1.5 K	1.5 K, 1/2 w, Fixed, Comp., 10%
R208	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%
R209	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%
R210	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%
R211	41-68 K	68 K, 1/2 w, Fixed, Comp., 10%
R212	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%
R213	56-16.2 K	16.2 K, 1/2 w, Fixed, MF, 1%
R214	56-4.64 K	4.64 K, 1/2 w, Fixed, MF, 1%
R215	44-1.0 Ω	1.0 Ω, 1/2 w, Fixed, Comp., 5%
R216	43-1 K	1 K, 2 w, Fixed, Comp., 10%
R217	41-39 K	39 K, 1/2 w, Fixed, Comp., 10%
R218	41-1.5 K	1.5 K, 1/2 w, Fixed, Comp., 10%
R219	56-2.61 K	2.61 K, 1/2 w, Fixed, MF, 1%
R220	56-2.61 K	2.61 K, 1/2 w, Fixed, MF, 1%
R221	71-91	500 Ω, Variable, 20 turn
R222	56-499 Ω	499 Ω, 1/2 w, Fixed, MF, 1%
R223	56-100 K	100 K, 1/2 w, Fixed, MF, 1%
R224	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%
R225	56-5.62 K	5.62 K, 1/2 w, Fixed, MF, 1%
R226	56-100 K	100 K, 1/2 w, Fixed, MF, 1%
R227	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%
R228	42-8.2 K	8.2 K, 1 w, Fixed, Comp., 10%
R229	44-1.0 Ω	1.0 Ω, 1/2 w, Fixed, Comp., 5%

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		RESISTORS (CONT)
R301	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%
R302	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%
R303	41-390 Ω	390 Ω, 1/2 w, Fixed, Comp., 10%
R304	56-3.83 K	3.83 K, 1/2 w, Fixed, MF, 1%
R305	56-7.50 K	7.50 K, 1/2 w, Fixed, MF, 1%
R306	56-1.02 K	1.02 K, 1/2 w, Fixed, MF, 1%
R307	56-19.6 K	19.6 K, 1/2 w, Fixed, MF, 1%
R308	56-82.5 K	82.5 K, 1/2 w, Fixed, MF, 1%
R309	71-93	10 K, Variable, 15 turn
R310	41-3.3 M	3.3 M, 1/2 w, Fixed, Comp., 10%
R311	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%
R312	41-390 Ω	390 Ω, 1/2 w, Fixed, Comp., 10%
R313	41-39 K	39 K, 1/2 w, Fixed, Comp.
R314	71-92	20 K, Variable, 15 turn
R315	41-3.3 M	3.3 M, 1/2 w, Fixed, Comp., 10%
R316	41-56 K	56 K, 1/2 w, Fixed, Comp., 10%
R317	56-2.37 K	2.37 K, 1/2 w, Fixed, MF, 1%
R318	56-1.33 K	1.33 K, 1/2 w, Fixed, MF, 1%
R319	56-15 K	15 K, 1/2 w, Fixed, MF, 1%
R320	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%
R321	56-14.7 K	14.7 K, 1/2 w, Fixed, MF, 1%
R401	43-2.2 K	2.2 K, 2 w, Fixed, Comp., 10%
R402	46-9.1 K	9.1 K, 2 w, Fixed, Comp., 5%
R403	41-27 K	27 K, 1/2 w, Fixed, Comp., 10%
R404	41-33 K	33 K, 1/2 w, Fixed, Comp., 10%
R405 *		Factory-Selected, nominal value 3.16 K
R406	41-47 K	47 K, 1/2 w, Fixed, Comp., 10%
R407	42-3.3 M	3.3 M, 1 w, Fixed, Comp., 10%
R408	42-3.3 M	3.3 M, 1 w, Fixed, Comp., 10%
R409	43-10 K	10 K, 2 w, Fixed, Comp., 10%
R410	41-15 K	15 K, 1/2 w, Fixed, Comp., 10%
R901	61-22	8 M, 5000 v, Fixed
R902		Not used
R903	42-1 K	1 K, 1 w, Fixed, Comp., 10%
R904	43-68 K	68 K, 2 w, Fixed, Comp., 10%
R905	42-1 K	1 K, 1 w, Fixed, Comp., 10%
R906	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R907	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R908	41-47 Ω	47 Ω, 1/2 w, Fixed, Comp., 10%
R909	42-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R910	42-1.8 K	1.8 K, 1 w, Fixed, Comp., 10%
R911	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R912	41-47 Ω	47 Ω, 1/2 w, Fixed, Comp., 10%
R913	41-10 Ω	10 Ω, 1/2 w, Fixed, Comp., 10%
R914		Not used
R915	43-68 K	68 K, 2 w, Fixed, Comp., 10%
R916	41-10 Ω	10 Ω, 1/2 w, Fixed, Comp., 10%
R917	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%
R918	43-68 K	68 K, 2 w, Fixed, Comp., 10%
R919	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%
R920	43-27 Ω	27 Ω, 2 w, Fixed, Comp., 10%
R921	63-8	25 Ω, 20 w, Fixed, WW
R922	55-42	1.05 Ω, 1/2 w, Fixed, WW, 1%
R923	71-41	5 K, Variable
R924	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R925	62-24	55 K, 10 w, Fixed, WW, 3%
R926	52-464 K	464 K, 1 w, Fixed, MF, 1%
R927	52-464 K	464 K, 1 w, Fixed, MF, 1%
R927	56-348 K	(560AC only) 348 K, 1/2 w, Fixed, MF, 1%
R928	56-100 K	100 K, 1/2 w, Fixed, MF, 1%
R928	56-71.5 K	(560AC only) 71.5 K, 1/2 w, Fixed, MF, 1%

* Factory Selected

GROUP 1

PARTS COMMON TO THE MODEL 560AC, 560AF AND 561AC (CONT)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		RESISTORS (CONT)
R932	41-39 Ω	Factory-Selected, nominal value 39 Ω
R933	41-27 Ω	27 Ω, 1/2 w, Fixed, Comp., 10%
R936	42-18 K	18 K, 1 w, Fixed, Comp., 10%
R937	41-4.7 K	4.7 K, 1/2 w, Fixed, Comp., 10%
R938	44-1.5 K	1.5 K, 1/2 w, Fixed, Comp., 5%
		INDUCTORS
L101	92-25	200 mh, choke, RF
L102	92-25	200 mh, choke, RF
L301	92-19	100 mh, coil, RF, 10%
		TRANSFORMERS
T901	91-191	AE950346C
T902	91-194	AE950380C
T903	91-192	AE950354C
T904	91-193	AE950378C
		RELAYS
K901	106-3	DPDT, 6 v
K902	106-19	3PDT, 6 v
K903	106-27	Time delay, 90 sec.
K904	106-24	SPDT, RS5D-10K
K905	106-24	SPDT, RS5D-10K
K906	106-13	DPDT, 6 v, DC
		METERS
M901	86-53	0 - 1 ma, 50 Ω, full scale, 2%
		SWITCHES
S901	101-3	Toggle
S902	102-128	Lever
S903	101-17	Interlock
S904	101-22	Air Flow Interlock
		VACUUM TUBES
V901	111-OA2	Tube, electron, OA2
V902	111-8068	Tube, electron, 8068
V903	111-7239	Tube, electron, 7239
V904	111-6GT5	Tube, electron, 6GT5
V905		Traveling Wave Tube
V906	111-6GT5	Tube, electron, 6GT5
		FUSES
F901	121-3	Fuse, 3 A
F902	121-14	Fuse, 2 A, slo-blo
		LAMPS
DS901	126-9	Indicator Panel
DS902	126-9	Indicator Panel
DS903	126-1	Lamp, Neon, NE-2
DS401	126-1	Lamp, Neon, NE-2

GROUP 2

PARTS COMMON TO THE MODEL 562AC AND 563AC

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		CAPACITORS
C101	13-33	10 mf, Fixed, Elect., 100 v
C102	13-33	10 mf, Fixed, Elect., 100 v
C103	14-13	1 mf, Fixed, Paper, 200 v
C104	12-41	10 pf, Fixed, Cer., 1000 v
C105	12-3	.01 mf, Fixed, Cer., 1000 v
C106	12-3	.022 mf, Fixed, Cer., 1000 v
C107	12-13	.005 mf, Fixed, Cer., 500 v
C201	12-3	.01 mf, Fixed, Cer., 1000 v
C202	12-34	.1 mf, Fixed, Cer., 100 v
C203	12-3	.01 mf, Fixed, Cer., 1000 v
C204	12-3	.01 mf, Fixed, Cer., 1000 v
C205	12-3	.01 mf, Fixed, Cer., 1000 v
C206	12-34	.1 mf, Fixed, Cer., 100 v
C207	13-40	100 mf, Fixed, Cer., 10 v
C301	12-34	.1 mf, Fixed, Cer., 100 v
C302		Not used
C303	12-34	.1 mf, Fixed, Cer., 100 v
C401	12-3	.01 mf, Fixed, Cer., 1000 v
C402	13-21	20 mf, Fixed, Elect., 250 v
C408	13-21	20 mf, Fixed, Elect., 250 v
C410	13-21	20 mf, Fixed, Elect., 250 v
C901	12-28	.001 mf, Fixed, Cer., 6000 v
C902	12-28	.001 mf, Fixed, Cer., 6000 v
C903	15-18	2 mf, Fixed, Paper, 2000 v
C904	15-18	2 mf, Fixed, Paper, 2000 v
C905	15-20	1 mf, Fixed, Paper, 3000 v
C906	12-30	1.5 pf, Fixed, Cer., 6000 v
C907		Not used
C908	12-3	.01 mf, Fixed, Cer., 1000 v
C909	12-3	.01 mf, Fixed, Cer., 1000 v
C910	12-3	.01 mf, Fixed, Cer., 1000 v
C911	12-3	.01 mf, Fixed, Cer., 1000 v
C912	12-34	.1 mf, Fixed, Cer., 100 v
C913	12-34	.1 mf, Fixed, Cer., 100 v
C914	13-4	150 mf, Fixed, Elect., 150 v
C915	13-36	100/100 mf, Fixed, Elect., 50 v
C916	13-9	3000 mf, Fixed, Elect., 15 v
C917	13-4	150 mf, Fixed, Elect., 150 v
C918		Not used
C919	16-5	.1 mf, Fixed, Plastic, 3000 v
		DIODES
CR101	81-41	1N459
CR102	81-41	1N459
CR103	81-41	1N459
CR104	81-41	1N459
CR105	81-41	1N459
CR106	81-41	1N459
CR107	81-41	1N459
CR108	81-41	1N459
CR201	81-41	1N459
CR202	81-41	1N459
CR203	81-75	Zener, 1N823 (6.2 v)
CR301	81-20	DI-26 or DI-46
CR302	81-20	DI-26 or DI-46
CR303	81-41	1N459
CR304	81-41	1N459
CR401	81-20	DI-46
CR402	81-57	Zener, 1/4 M15Z10

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		DIODES (CONT)
CR403	81-20	DI-46
CR404	81-20	DI-46
CR901	81-69	H. V. Rectifier DI-1154
CR902		Not used
CR903		Not used
CR904	81-20	DI-46
CR905	81-20	DI-46
CR906	81-20	DI-46
CR907	81-20	DI-46
CR908	81-93	MR322R
CR909	81-93	MR322R
CR911	81-125	1N4756
CR919	81-41	1N454
CR920	81-41	1N454
		TRANSISTORS
Q101	81-114	2N3638
Q102	81-114	2N3638
Q103	81-114	2N3638
Q104	81-72	2N699
Q105	81-114	2N3638A
Q106	81-114	2N3638
Q107	81-71	2N697
Q108	81-72	2N699
Q109	81-72	2N699
Q201	81-51	2N404
Q202	81-72	2N699
Q203	81-51	2N404
Q204	81-51	2N404
Q205	81-73	2N706
Q206	81-73	2N706
Q207		Not used
Q208	81-72	2N699
Q209	81-51	2N404
Q210	81-51	2N404
Q211	81-73	2N706
Q212	81-73	2N706
Q301	81-72	2N699
Q302	81-51	2N404
Q303	81-51	2N404
Q304	81-90	S6793
Q305	81-90	S6793
Q306	81-90	S6793
Q307	81-90	S6793
Q308	81-72	2N699
Q309	81-72	2N699
Q401	81-72	2N699
Q402	81-72	2N699
Q901	81-112	40251
Q902	81-86	2N2147
Q903	81-74	2N1540
Q904	81-71	2N697
Q912	81-77	Zener, 1N752A
		RESISTORS
R101	56-7.5 K	7.5 K, 1/2 w, Fixed, MF, 1%
R102	56-1 K	1 K, 1/2 w, Fixed, MF, 1%
R103	41-560 K	560 K, 1/2 w, Fixed, Comp., 10%
R104	56-19.6 K	19.6 K, 1/2 w, Fixed, MF, 1%
R105	56-14.7 K	14.7 K, 1/2 w, Fixed, MF, 1%

PARTS COMMON TO THE MODEL 562AC AND 563AC (CONT)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		RESISTORS (CONT)
R106	56-3.83 K	3.83 K, 1/2 w, Fixed, MF, 1%
R107	56-16.2 K	16.2 K, 1/2 w, Fixed, MF, 1%
R108	56-31.6 K	31.6 K, 1/2 w, Fixed, MF, 1%
R109	41-56 K	56 K, 1/2 w, Fixed, Comp., 10%
R110	41-100 K	100 K, 1/2 w, Fixed, Comp., 10%
R111	56-46.4 K	46.4 K, 1/2 w, Fixed, MF, 1%
R112	41-100 K	100 K, 1/2 w, Fixed, Comp., 10%
R113	43-2.2 K	2.2 K, 2 w, Fixed, Comp., 10%
R114	41-100 K	100 K, 1/2 w, Fixed, Comp., 10%
R115	41-560 K	560 K, 1/2 w, Fixed, Comp., 10%
R116	56-26.1 K	26.1 K, 1/2 w, Fixed, MF, 1%
R117	56-162 K	162 K, 1/2 w, Fixed, MF, 1%
R118	41-15 K	15 K, 1/2 w, Fixed, Comp., 10%
R119	71-93	10 K, Variable, 20 turn
R120	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%
R121	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%
R122 *	41-3.3 M	3.3 M, 1/2 w, Fixed, Comp., 10%
R123	41-47 K	47 K, 1/2 w, Fixed, Comp., 10%
R124	41-10 Ω	10 Ω, 1/2 w, Fixed, Comp., 10%
R125	43-3.3 K	3.3 K, 2 w, Fixed, Comp., 10%
R126	56-10 K	10 K, 1/2 w, Fixed, MF, 1%
R127	56-4.99 K	4.99 K, 1/2 w, Fixed, MF, 1%
R128	56-52.3 K	52.3 K, 1/2 w, Fixed, MF, 1%
R129	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%
R130	43-15 K	15 K, 2 w, Fixed, Comp., 10%
R131	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%
R132	41-47 K	47 K, 1/2 w, Fixed, Comp., 10%
R201	56-5.62 K	5.62 K, 1/2 w, Fixed, MF, 1%
R202	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%
R203	56-7.50 K	7.50 K, 1/2 w, Fixed, MF, 1%
R204	56-10 K	10 K, 1/2 w, Fixed, MF, 1%
R205	51-8.2 K	8.2 K, 1/2 w, Fixed, Comp., 10%
R206	42-1 K	1 K, 1 w, Fixed, Comp., 10%
R207	41-1.5 K	1.5 K, 1/2 w, Fixed, Comp., 10%
R208	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%
R209	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%
R210	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%
R211	41-68 K	68 K, 1/2 w, Fixed, Comp., 10%
R212	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%
R213	56-16.2 K	16.2 K, 1/2 w, Fixed, MF, 1%
R214	56-4.64 K	4.64 K, 1/2 w, Fixed, MF, 1%
R215	44-1.0 Ω	1.0 Ω, 1/2 w, Fixed, Comp., 5%
R216	43-1 K	1 K, 2 w, Fixed, Comp., 10%
R217	41-39 K	39 K, 1/2 w, Fixed, Comp., 10%
R218	41-1.5 K	1.5 K, 1/2 w, Fixed, Comp., 10%
R219	56-2.61 K	2.61 K, 1/2 w, Fixed, MF, 1%
R220	56-2.61 K	2.61 K, 1/2 w, Fixed, MF, 1%
R221	71-91	500 Ω, Variable, 20 turn
R222	56-499 Ω	499 Ω, 1/2 w, Fixed, MF
R223	56-100 K	100 K, 1/2 w, Fixed, MF
R224	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp.
R225	56-5.62 K	5.62 K, 1/2 w, Fixed, MF
R226	56-100 K	100 K, 1/2 w, Fixed, MF, 1%
R227	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%
R228	42-8.2 K	8.2 K, 1 w, Fixed, Comp., 10%
R229	44-1.0 Ω	1.0 Ω, 1/2 w, Fixed, Comp., 5%
R301	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%
R302	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%
R303	41-390 Ω	390 Ω, 1/2 w, Fixed, Comp., 10%
R304	56-3.83 K	3.83 K, 1/2 w, Fixed, MF, 1%
R305	56-7.50 K	7.50 K, 1/2 w, Fixed, MF, 1%

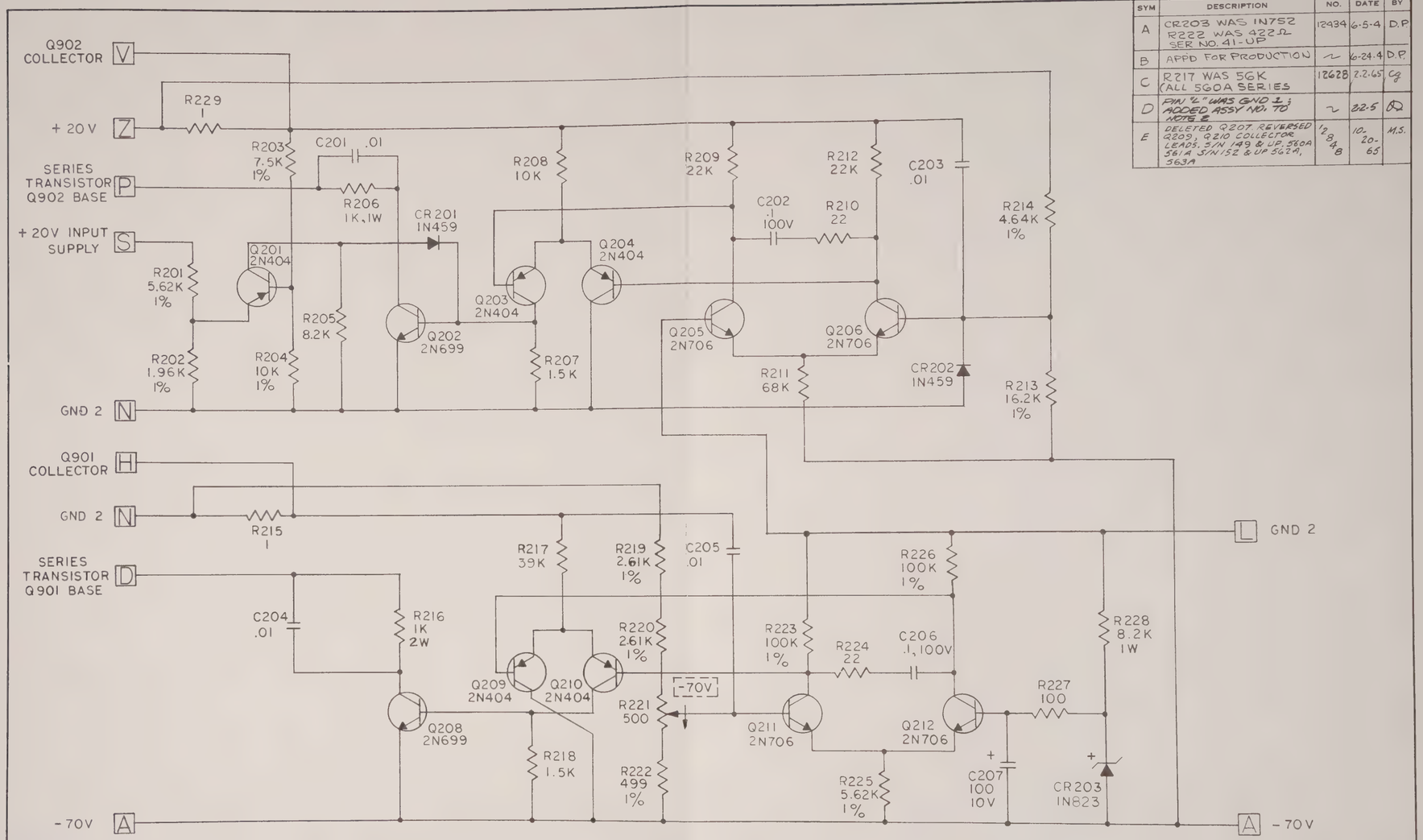
CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		RESISTORS (CONT)
R306	56-1.02 K	1.02 K, 1/2 w, Fixed, MF, 1%
R307	56-19.6 K	19.6 K, 1/2 w, Fixed, MF, 1%
R308	56-82.5 K	82.5 K, 1/2 w, Fixed, MF, 1%
R309	71-93	10 K, Variable, 15 turn
R310	41-3.3 M	3.3 M, 1/2 w, Fixed, Comp., 10%
R311	41-22 K	22 K, 1/2 w, Fixed, Comp., 10%
R312	41-390 Ω	390 Ω, 1/2 w, Fixed, Comp., 10%
R313	41-39 K	39 K, 1/2 w, Fixed, Comp., 10%
R314	71-92	20 K, Variable, 15 turn
R315	41-3.3 M	3.3 M, 1/2 w, Fixed, Comp., 10%
R316	41-56 K	56 K, 1/2 w, Fixed, Comp., 10%
R317	56-2.37 K	2.37 K, 1/2 w, Fixed, MF, 1%
R318	56-1.33 K	1.33 K, 1/2 w, Fixed, MF, 1%
R319	56-15 K	15 K, 1/2 w, Fixed, MF, 1%
R320	56-1.96 K	1.96 K, 1/2 w, Fixed, MF, 1%
R321	56-14.7 K	14.7 K, 1/2 w, Fixed, MF, 1%
R401	43-2.2 K	2.2 K, 2 w, Fixed, Comp., 10%
R402	43-15 K	15 K, 2 w, Fixed, Comp., 10%
R403	41-12 K	12 K, 1/2 w, Fixed, Comp., 10%
R404	41-27 K	27 K, 1/2 w, Fixed, Comp., 10%
R405	56-3.83 K	3.83 K, 1/2 w, Fixed, MF, 1%
R406	41-47 K	47 K, 1/2 w, Fixed, Comp., 10%
R407		Not used
R408		Not used
R409	43-2.2 K	2.2 K, 2 w, Fixed, Comp., 10%
R410	41-100 Ω	100 Ω, 1/2 w, Fixed, Comp., 10%
R901	61-22	8 M, 5000 v, Fixed
R902	61-22	8 M, 5000 v, Fixed
R903	42-1 K	1 K, 1 w, Fixed, Comp., 10%
R904	43-68 K	68 K, 2 w, Fixed, Comp., 10%
R905	42-1 K	1 K, 1 w, Fixed, Comp., 10%
R906	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R907	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R908		Not used
R909		Not used
R910		Not used
R911		Not used
R912		Not used
R913	41-10 Ω	10 Ω, 1/2 w, Fixed, Comp., 10%
R914		Not used
R915	43-68 K	68 K, 2 w, Fixed, Comp., 10%
R916	41-10 Ω	10 Ω, 1/2 w, Fixed, Comp., 10%
R917	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%
R918	43-68 K	68 K, 2 w, Fixed, Comp., 10%
R919	41-22 Ω	22 Ω, 1/2 w, Fixed, Comp., 10%
R920	43-27 Ω	27 Ω, 2 w, Fixed, Comp., 10%
R921	63-8	25 Ω, 20 w, Fixed, WW
R922	55-42	1.05 Ω, 1/2 w, Fixed, WW, 1%
R923	71-41	5 K, Variable
R924	41-1 K	1 K, 1/2 w, Fixed, Comp., 10%
R925	62-24	55 K, 10 w, Fixed, WW, 3%
R926	52-464 K	464 K, 1 w, Fixed, MF, 1%
R927	52-464 K	464 K, 1 w, Fixed, MF, 1%
R928	52-464 K	464 K, 1 w, Fixed, MF, 1%
R929	52-464 K	464 K, 1 w, Fixed, MF, 1%
R930	52-464 K	464 K, 1 w, Fixed, MF, 1%
R931	56-118 K	118 K, 1/2 w, Fixed, MF, 10%
R931	52-464 K	(for 563AC only) 464 K, 1 w, Fixed, MF, 1%
R932	41-68 Ω	68 Ω, 1/2 w, Fixed, Comp., 10%
R932	56-215 K	(for 563AC only) 215 K, 1/2 w, Fixed, MF, 1%
R933	41-27 Ω	27 Ω, 1/2 w, Fixed, Comp., 10%
R934	41-39 Ω	Factory-Selected, nominal value 39 Ω

* Factory Selected

PARTS COMMON TO THE MODEL 562AC AND 563AC (CONT)

CIRCUIT REFERENCE	ALFRED PART NO.	DESCRIPTION
		RESISTORS (CONT)
R935	41-10 K	10 K, 1/2 w, Fixed, Comp., 10%
R936		Not used
R937	41-4.7 K	4.7 K, 1/2 w, Fixed, Comp., 10%
R938	44-1.5 Ω	1.5 Ω, 1/2 w, Fixed, Comp., 5%
		INDUCTORS
L301	92-19	100 mf, coil, RF, 10%
		TRANSFORMERS
T901	91-191	AE 950346C
T902	91-194	AE 950380C
T903	91-192	AE 950354C
T904	91-193	AE 950378C
		RELAYS
K901	106-3	DPDT, 6 v, AC
K902	106-19	3PDT, 6 v
K903	106-27	Time Delay, 90 sec.
K904	106-24	SPDT, RS5D-10K
K905	106-24	SPDT, RS5D-10K
K906	106-13	DPDT, 6 v, DC
		METERS
M901	86-53	0 - 1 ma, 50 Ω, full scale, 2%
		SWITCHES
S901	101-3	Toggle
S902	102-128	Lever
S903	101-17	Interlock
S904	101-22	Airflow Interlock
		VACUUM TUBES
V901	111-OA2	Tube, electron, OA2
V902	111-8068	Tube, electron, 8068
V903	111-7239	Tube, electron, 7239
V905		Traveling wave tube
		FUSES
F901	121-3	Fuse, 3 A
F902	121-14	Fuse, 2 A, slo-blo
		LAMPS
DS901	126-9	Indicator Panel
DS902	126-9	Indicator Panel
DS401	126-1	Lamp, Neon NE-2
		TRAVELING WAVE TUBES FOR THE 560A SERIES
	Model 560AC	V905, Stewart, SYT-4268
	Model 560AF	V905, Warnecke, WR-130
	Model 561AC	V905, Stewart, SYT-4260K
	Model 562AC	V905, Stewart, SYT-4278K
	Model 563AC	V905, Stewart, SYT-4273K

SYM	DESCRIPTION	NO.	DATE	BY
A	CR203 WAS IN752 R222 WAS 422Ω SER NO. 41-UP	12434	6-5-64	D.P
B	APPD FOR PRODUCTION	~	6-24-64	D.P
C	R217 WAS 56K (ALL 560A SERIES	12628	2-2-65	CG
D	PIN "L" WAS GND 2 ; ADDED ASSY NO. 70 NOTE 2	~	12-5	RD
E	DELETED Q207. REVERSED Q209, Q210 COLLECTOR LEADS. S/N 149 & UP. 560A 561A S/N 152 & UP 562A, 563A	12978	10-20-65	M.S.



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2 W, 10%.
   1B. ALL 1% RESISTORS ARE METAL FILM TYPE.
   1C. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE (□) DESIGNATES PRINTED WIRING BOARD CONNECTION ON PC 200, ASSEMBLY NO. 950389

ITEM	REQD	PART NO.	DESCRIPTION
			LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN D.J. MACKAIG 2-2-64

ENG

PROD

SCALE

— SCHEMATIC —
LOW VOLTAGE SUPPLIES
(+20V & -70V)

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

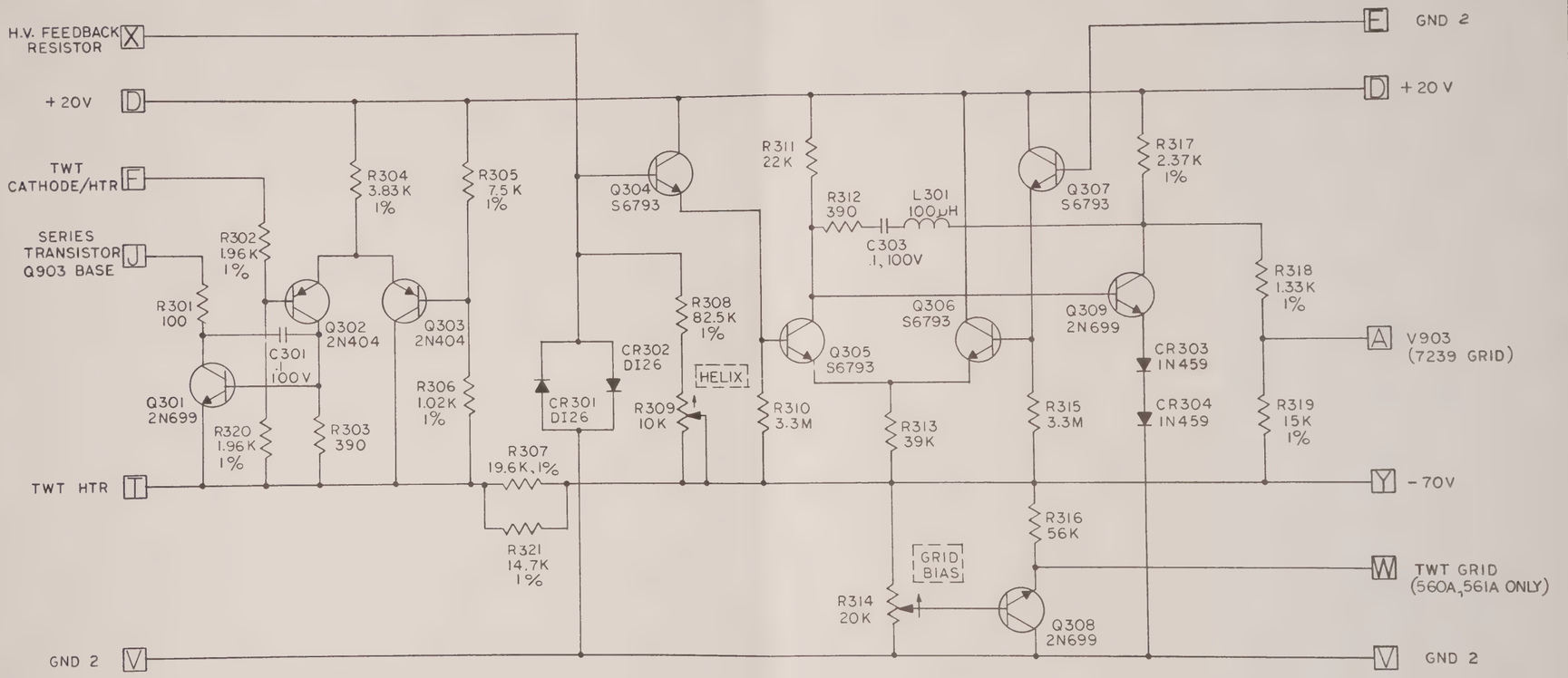
S/N 152-UP	562A/563A
S/N 149-UP	560A/561A
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900682C

SHEET 1 OF 1

SYM	DESCRIPTION	NO.	DATE	BY
A	R306 WAS 1.05K EFFECTIVE S/N 21-UP	12911	5-16-64	D.P.
B	APPD FOR PRODUCTION	~	6-29-64	D.P.
C	DELETED C302 SER. NO. 11-UP	12516	9-15-64	D.P.
D	ADDED "560A/561A ONLY" TO P/N W	~	2-22-65	DD



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   - 1A. ALL RESISTORS IN OHMS, 1/2 W, 10%.
   - 1B. ALL 1% RESISTORS ARE METAL FILM TYPE.
   - 1C. ALL CAPACITORS IN MICROFARADS, 500 V.
2. SQUARE (□) DESIGNATES PRINTED WIRING BOARD CONNECTION ON PC300, ASSEMBLY NO. 950390.

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO

FINISH OR TREATMENT

DRAWN D.J. MACKAIG DATE

ENG John N Francis 6-24-64

PROD Alan D. Nelson 6-24-64

SCALE

— SCHEMATIC — HEATER & HIGH VOLTAGE SUPPLIES

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

NEXT ASSY: 560A SERIES

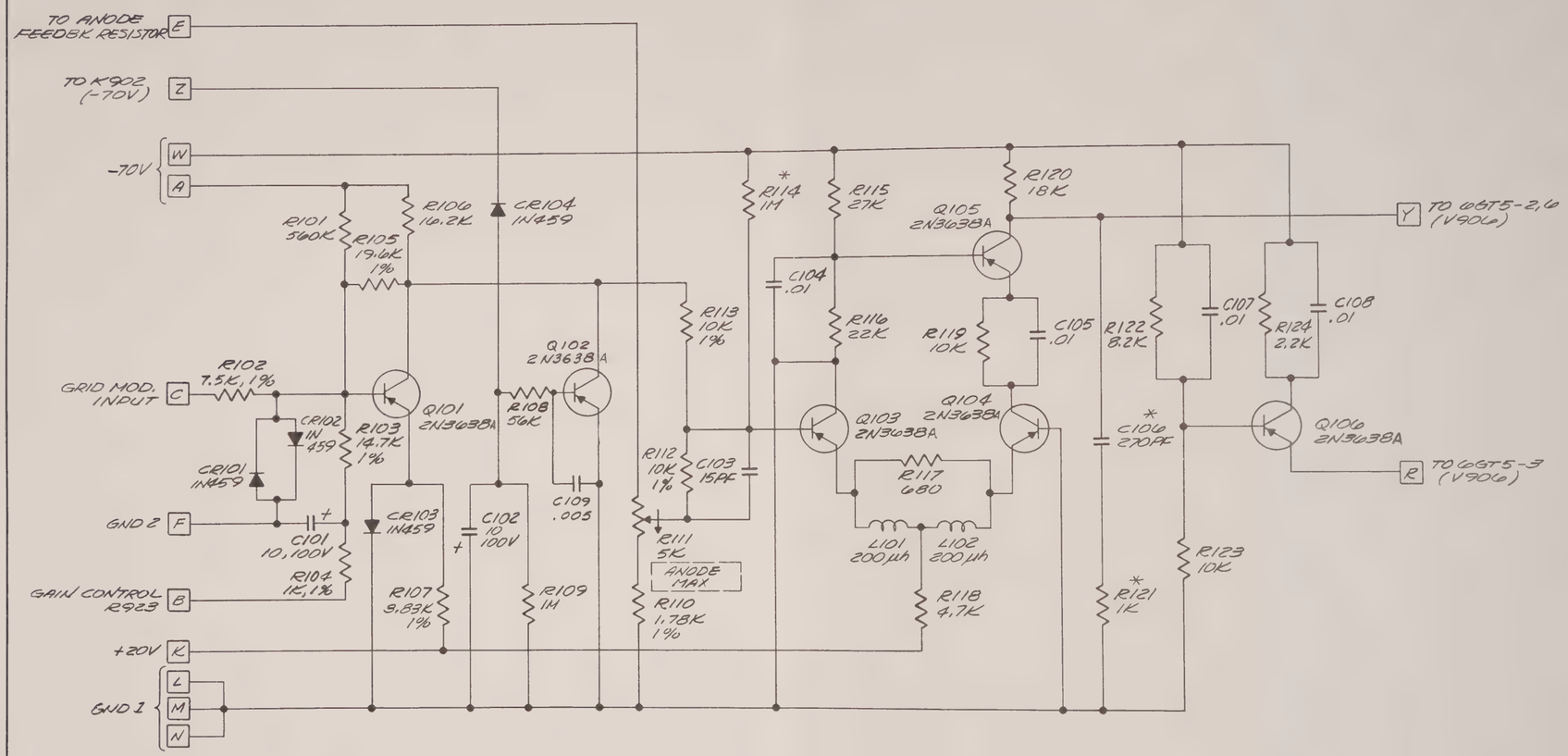
USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900683C

SHEET 1 OF 1

SYM	DESCRIPTION	NO.	DATE	BY
A	APPROVED FOR PROD. REPLACED 900681C.	12598	1-8-65	[illegible]
	R120 WAS 22K, R102 WAS 10K, R108 WAS 220K, R109 WAS 1M. R114, R121, C106 MADE FACTORY SELECT. S/N 130 & UP	12811	8-24-65	MS
B	ADDED C107. S/N 155 & UP	12812	9-1-65	MS
C	R109 WAS 100K. S/N 130 & UP	12811B	11-9-65	MS



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   - 1A. ALL RESISTORS IN OHM, 1/2W, 10%
   - 1B. ALL CAPACITORS IN MICROFARAD, 500V
   - 1C. ALL RESISTORS 1% ARE METAL FILM
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON ASSY "PC100", ASSEMBLY NO. 950891

* FACTORY SELECTED

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL	
MATERIAL STOCK NO.	
FINISH OR TREATMENT	

		DATE
DRAWN	[illegible]	12-19-64
ENG	Ralph Britt	1-8-65
PROD	[illegible]	1-11-65
SCALE		

SCHEMATIC
HIGH VOLTAGE ANODE SUPPLY

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½° UNLESS INDICATED OTHERWISE

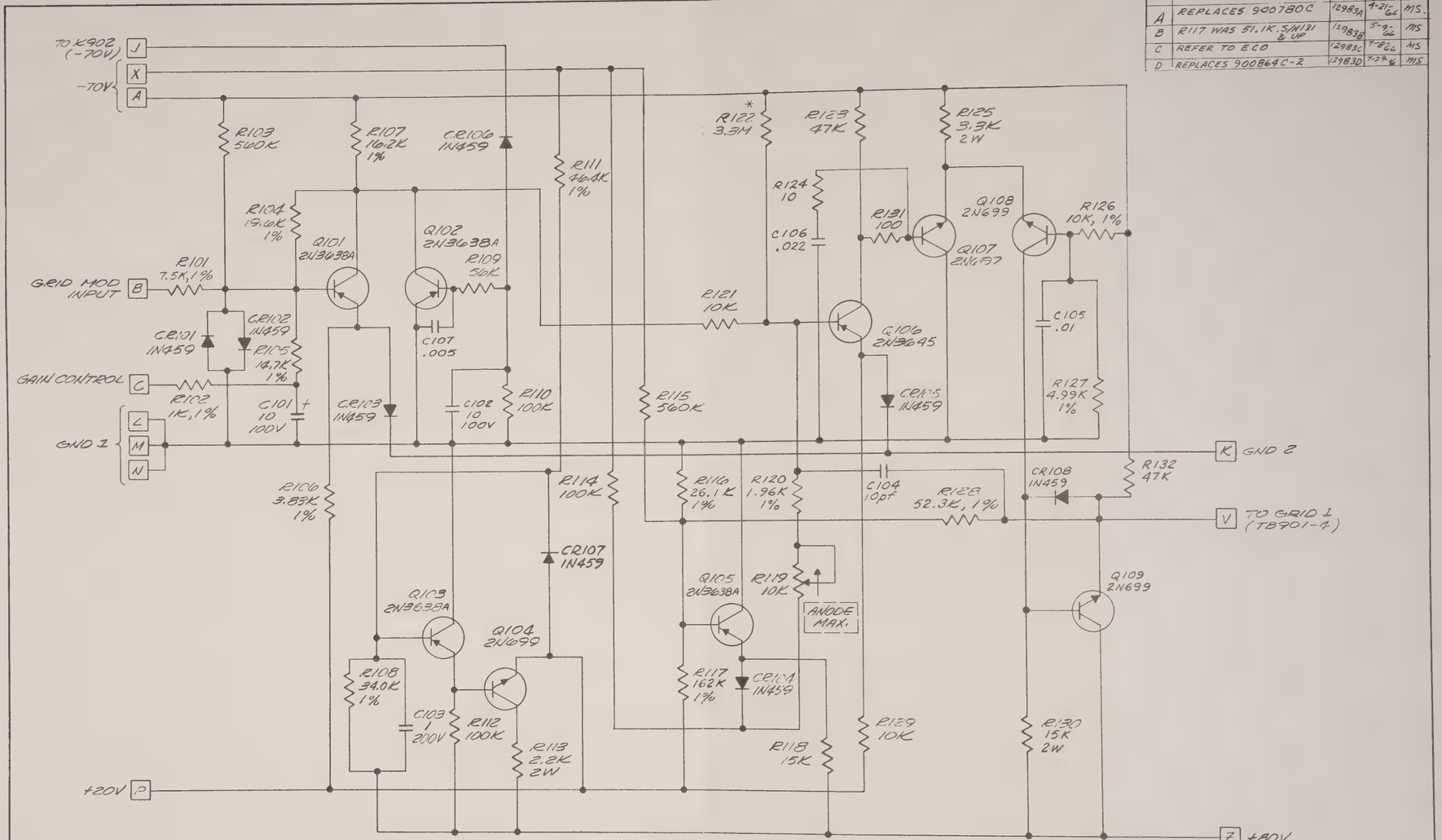
95, 75 & UP	560AF
95, 75 & UP	561AC
95, 75 & UP	560AC
NEXT ASSY	USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900778C

SHEET 1 OF 1

SYM	DESCRIPTION	NO.	DATE	BY
A	REPLACES 900780C	129834	4-21-66	MS
B	R117 WAS 51.1K. S/N 181 & UP	129838	5-9-66	MS
C	REFER TO ECO	129830	7-8-66	MS
D	REPLACES 900864C-2	129830	7-28-66	MS



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   - 1A. ALL RESISTORS IN OHMS, 1/2W, 10%
   - 1B. ALL CAPACITORS IN MICROFARADS, 500V
   - 1C. ALL RESISTORS 1% ARE METAL FILM
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON ASSY "PC100", ASSEMBLY NO. 901463

* FACTORY SELECTED.

ITEM	REQD	PART NO.	DESCRIPTION
			LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN MCJ Stow 1-8-65

ENG 1-11-65

PROD 1-11-65

SCALE

SCHEMATIC
LOW VOLTAGE
ANODE SUPPLY

DIMENSIONS ARE IN INCHES
TOL: .XX ± .015, .XXX ± .005, ANGLE ± ½°
UNLESS INDICATED OTHERWISE

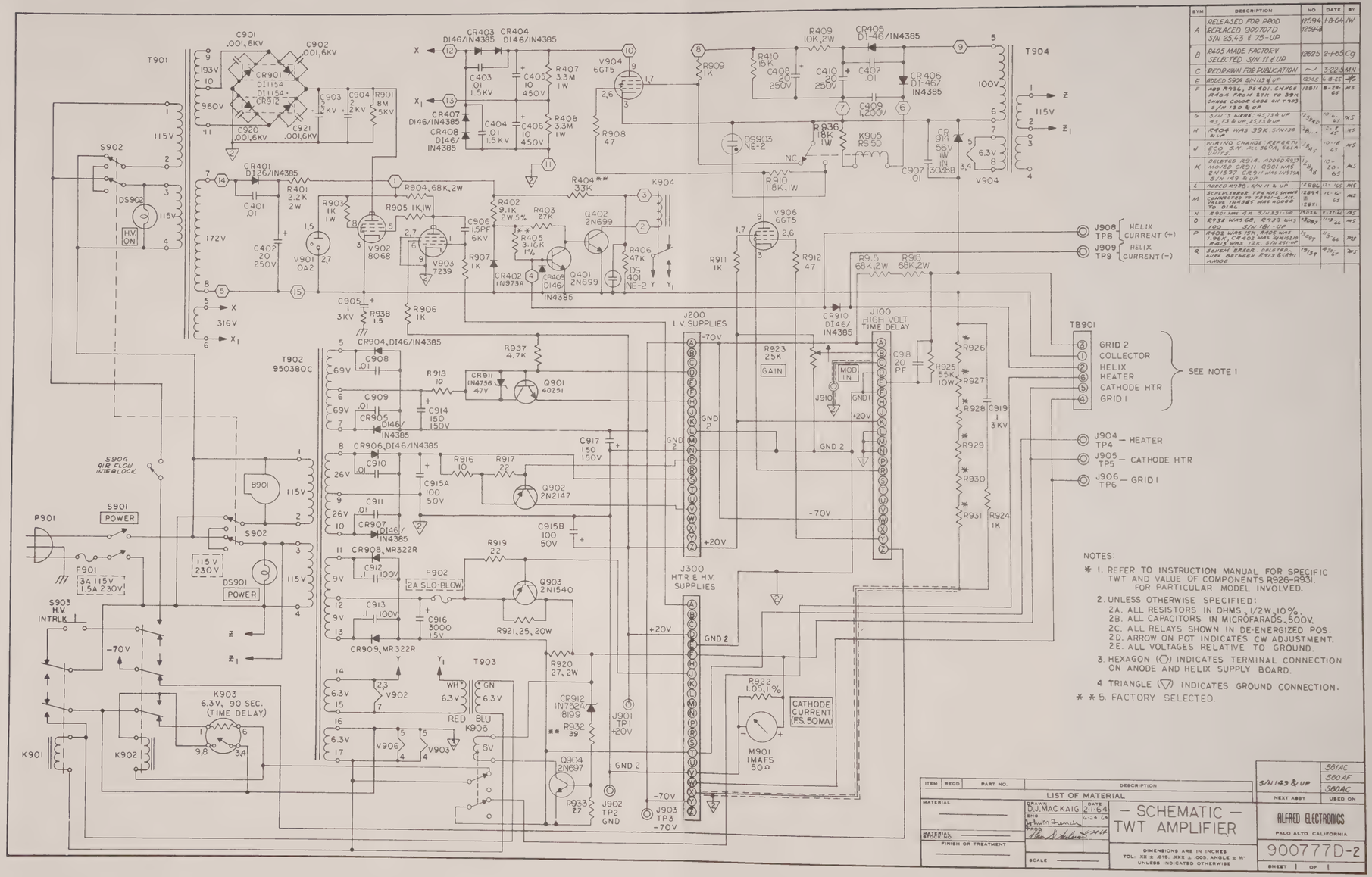
ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900864C-3

SHEET 1 OF 1

181-UP	563AC
181-UP	562AC
NEXT ASSY	USED ON

BYM	DESCRIPTION	NO	DATE	BY
	RELEASED FOR PROD	12594	1-8-64	IW
A	REPLACED 900707D S/N 25 & 43 & 75 - UP	12594A		
B	R405 MADE FACTORY SELECTED S/N 11 & UP	12625	2-1-65	CG
C	REDRAWN FOR PUBLICATION	~	3-22-65	MN
E	ADDED 5908 S/N 13 & UP.	12745	6-8-65	JHC
F	ADD R936, D5401. CHANGE R406 FROM 27K TO 39K CHANGE COLOR CODE ON T903 S/N 130 & UP	12811	8-24-65	MS
G	S/N 3 WERE: 45, 73 & UP 43, 73 & UP, 25, 73 & UP	12598D	10-14-65	MS
H	R406 WAS 39K. S/N 130 & UP	12811A	12-1-65	MS
J	WIRING CHANGE. REFER TO ECO S.N. ALL 560A, 561A UNITS.	12845	10-18-65	MS
K	DELETED R914. ADDED R937 MOVED C911, Q901 WAS 2N1537, C&Q/ WAS IN 5904 S/N 149 & UP	12908	12-20-65	MS
L	ADDED R938. S/N 11 & UP.	12886	12-16-65	MS
M	SCHEMATIC ERROR: T903 WAS SHOWN CONNECTED TO T8901-6. ADD VALUE 1N4385 WAS ADDED TO D146	12894 & 12811	12-16-65	MS
N	R901 WAS 6M S/N 231-UP	13026	4-27-66	MS
O	R932 WAS 68, R933 WAS 100 S/N 181-UP	13097	5-23-66	MS
P	R402 WAS 15K, R405 WAS 1.96K, C402 WAS 40 S/N 2120 R413 WAS 12K S/N 251-UP	13097	5-23-66	MS
Q	SCHEM. ERROR. DELETED NPN BETWEEN R913 & CR911 ANODE	13159	8-12-66	MS



ITEM	REQD	PART NO.	DESCRIPTION
			LIST OF MATERIAL

MATERIAL

MATERIAL STOCK NO.

FINISH OR TREATMENT

DRAWN D.J. MAC KAIG DATE 2-1-64

ENG

PROD

SCALE

— SCHEMATIC — TWT AMPLIFIER

DIMENSIONS ARE IN INCHES
TOL. .XX ± .015, .XXX ± .005 ANGLE ± ½°
UNLESS INDICATED OTHERWISE

S/N 149 & UP — NEXT ASSY

561AC
560AF
560AG
USED ON

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900777D-2

SHEET 1 OF 1

SYM	DESCRIPTION	NO.	DATE	BY
A	RELEASED TO PROD. REPLACED 900680D S/N 30, 73 UP	12594 12948	1-27-5	IW
B	Z & Z1 WAS CONNECTED TO T902 SEC NO 10, 73 & UP. J405 MADE FACTORY SELECTED S/N 116 UP	12827 12825	2-1-5	CS
C	REDRAWN FOR MANUAL	—	3-19-5	MN
D	SCHEMATIC ERROR TB901 #6 AND 3 WERE INTERCHANGED	13005	4-30-5	MN
E	ADDED 3904 S/N 110 & UP	12705	6-18-5	MS
F	R404 WAS 27K, R935 WAS 6.8K. ADDED D5401 T903 COLOR CODE WAS WH-WH, GN-GN. S/N 133 & UP	1EB11	8-24-65	MS
G	3/27/3 WAS 73 & UP. 30, 73 & UP.	13340	10-6-65	MS
H	R404 WAS 33K S/N 138 & UP	12811A	10-18-65	MS
J	WIRING CHANGE, REFER TO ECR S.N. ALL 3684, 563A UNITS	12845	10-18-65	MS
K	DELETED R914. ADDED RESIST. ACROSS CR911. C901 WAS 1N1587, CR911 WAS 1N3754. S/N 152 & UP	12848	10-20-65	MS
L	ADDED R938 S/N 118 & UP	12886	12-6-65	MS
M	SCHEM. ERROR: TP4 WAS SHOWN CONNECTED TO TB901-6 NOT 4. VALUE 1N4382 ADDED TO D914	12894 & 1E871	12-16-65	MS
N	R409 WAS 2.7K. S/N 181-UP	13034	8-10-66	MS
O	R901, R902 WERE 4M S/N 193-UP	13026	9-15-66	MS
P	R934 WAS 68, R933 WAS 100. S/N 181 - UP	14087	1-3-67	MS
Q	SCHEM. ERROR, DELETED WIRE BETWEEN R913 & CR911 ANODE	13139	4-24-67	MS

SEE NOTE 1

T301: 193V, 10, 11, 950V, 115V, 172V, 316V

CR901A D1N154; CR901B D1N154

C901 .001 6KV; C902 .001 6KV; C903 2 2KV; C904 2 2KV

R901 8M 5KV 4W 20%; R902 8M 5KV 4W 20%

S902; DS902 HV ON; Z; Z1

CR401 D1A6/IN4385; C401 .01; R401 2.2K 2W; C402 20 250V

R903 1K 1W; R904 68K 2W; R905 1K 1W; V901 0A2; V902 306B; V903 7239

C906 15 PF 6KV; R907 1K; C2402 14 MISZ10

R402 15 K 2W; R403; R404 ** 33K; R405 ** 3.03K 1%

Q401 2N699; Q402 2N6589; CR409 D1A6/IN4385; D5401 WE-2V

K904; Y1

R906 1K; C905 1 3KV; R938 1.5

T902: 69V, 69V, 26V, 26V, 9V, 9V

CR904, D1A6/IN4385; C908 .01; CR913 1N459; R913 10; R935 10K; CR911 1N4756 47V; R937 4.7K; Q901 2N251

C909 .01; CR905 D1A6/IN4385; C914 150 150V; K905

CR920 1N459; C917 150 150V

CR906 D1A6/IN4385; C910 .01; C915A 100 50V; R916 10; R917 22; Q902 2N2147

C911 .01; CR907 D1A6/IN4385; C915B 100 50V

CR908 MR322R; C912 .1 100V; R919 22; Q903 2N1540

F902 2A SLO-BLOW; C913 .1 100V; C916 3000 15V; R921, 25, 20W

CR909, MR322R; R920, 27, 2W; CR912 1N752A/ 1B199

T903: 14, 6.3V, 2.3, V902; 15, 6.3V; 16, 6.3V, V903; 17; WH 6.3V RED; GN 6.3V BLU

K906 6V; R934 39; Q904 2N697; R933 27; J902 TP2 GND; J903 TP3 -70; J901 TP1 +20V; GND 2

S904 AIR FLOW INTERLOCK; S901 POWER; P901; F901 3A 115V 1.5A 230V; S903 H.V. INTRLK; K901; K902; K903 6.3V, 90 SEC. (TIME DELAY); 98; 34

B901; 115V; 115V 230V; DS901 POWER; 115V

V200 L.V. SUPPLIES -70

J300 HTR & H.V. SUPPLIES; +20V

J100 LOW VOLTAGE ANODE SUPPLY; +20

R923 5K GAIN; J910 MOD. IN

CR910 D1A6/IN4385

R409 2.2K, 2W; C408 20 250V; C405 D1A6/IN4385; C410 20 250V; R410 100; N.C; N.O

T904: 100V, 6.3V; 1 Z; 2 Z1

J908 TP8 HELIX CURRENT (+); J909 TP9 HELIX CURRENT (—)

TB901: 3 GRID, 7 COLLECTOR, 2 HELIX, 6 HEATER, 5 CATHODE HTR, 4 — SEE NOTE 1

J904 TP4 HEATER; J905 TP5 CATHODE HTR

R926 *; R927 *; R928 *; R929 *; R930 *; R931 *; R932 *; C919 1 3KV; R924 1K

R922 105, 1% CATHODE CURRENT (FS 50MA); M901 1MA FS 50Ω

NOTES:

* 1. REFER TO INSTRUCTION MANUAL FOR SPECIFIC TWT AND VALUE OF COMPONENTS R926-R932 FOR PARTICULAR MODEL INVOLVED.

2. UNLESS OTHERWISE SPECIFIED:
   2A. ALL RESISTORS IN OHMS, 1/2 W, 10 %.
   2B. ALL CAPACITORS IN MICROFARADS, 500 V.
   2C. ALL RELAYS SHOWN IN DE-ENERGIZED POS.
   2D. ARROW ON POT INDICATES CW ADJUSTMENT.
   2E. ALL VOLTAGES RELATIVE TO GROUND.

3. HEXAGON (⬡) INDICATES TERMINAL CONNECTION ON ANODE AND HELIX SUPPLY BOARD.

4. TRIANGLE (▽) INDICATES GROUND CONNECTION.

* * 5. FACTORY SELECTED.

ITEM	REQD	PART NO.	DESCRIPTION

LIST OF MATERIAL

MATERIAL	DRAWN Margaretha Meeks	DATE 1-5-65
	ENG Ralph Britton	1-11-65
MATERIAL STOCK NO.	PROG. A. Anderson	1-11-65
FINISH OR TREATMENT	SCALE	

DIMENSIONS ARE IN INCHES
TOL: XX ± .015 .XXX ± .005 ANGLE ± ½°
UNLESS INDICATED OTHERWISE

-SCHEMATIC-
TWT AMPLIFIER

ALFRED ELECTRONICS
PALO ALTO, CALIFORNIA

900779D-2

SHEET 1 OF 1

S/N 152 & UP	563AC
NEXT ASSY	562AC
	USED ON

TRAVELING-WAVE TUBE

ENGINEERING NOTES

GENERAL INFORMATION ON TRAVELING-WAVE TUBES

R. A. Huggins*

Engineers who design circuits which use conventional low frequency vacuum tubes usually have at least a speaking acquaintance with their theory of operation. In designing circuits, or in deciding which type of tube to use, careful use is made of the various characteristic curves associated with these tubes. The following discussion will similarly acquaint the applications engineer with the simple theory of the operation of the traveling-wave tube and familarize him with the various characteristic curves which describe its operation.

MICROWAVE AMPLIFICATION

As the microwave region of the radio frequency spectrum came into practical engineering use, devices were needed which could function as better amplifiers and oscillators. Above a few hundred megacycles conventional vacuum tubes no longer amplify properly because the period of one cycle of the radio frequency wave approaches the time it takes the electrons to travel from cathode to anode. As a result the amplification factor of the tube decreases with increasing frequency until no useful gain can be obtained. This is known as the transit time effect.

The first device which served as a practical amplifier above a few hundred megacycles actually made use of the transit time effect. This device, known as a klystron, became useful primarily as an oscillator. The klystron, however, is also capable of acting as an amplifier. Klystron amplifiers are capable of giving high values of amplification, but they have two serious limitations for many applications: They are relatively narrow band devices which usually have no more than a few megacycles bandwidth between half-power points, and tuning the amplifier to different frequencies requires a mechanical adjustment. The klystron is, however, the forerunner of a general class of microwave electron devices which utilize transit time effects in electron beams. This general class of devices includes the traveling-wave tube (TWT).

A klystron is a narrow band device because it involves the use of a very sharply resonant, high-impedance tuned circuit. It is necessary for a klystron to use such a circuit because interaction takes place with the electrons over very short physical distances, and it must develop high electric fields to have efficient interaction with the electrons. It was reasoned, however, that one might obtain a very broadband amplifying device by using a low-impedance, broadband circuit which developed relatively small electric fields that interacted with the electrons over a long physical distance. Such is the basis on which the traveling-wave tube works, and this basic concept led to a wide range of devices which are useful as broadband amplifiers and oscillators in the microwave region.

The traveling-wave tube yields high values

* President, Huggins Laboratories, Inc.

of amplification over wide frequency ranges with no mechanical tuning mechanism or variation of any voltages or currents applied to the tube. Power amplification greater than 10,000 (i.e., 40 db gain) over a 2:1 frequency range has been obtained with this type of tube. The actual number of megacycles covered by such tubes can be a staggering figure. For example, an operating bandwidth of 2000 megacycles has been obtained in one typical tube type; 7000 megacycles has been obtained in another.

Tubes can be designed to emphasize various special characteristics. For instance, tubes are built which have low noise properties, high power output, or controlled variations of gain with frequency. Many special tubes are designed and built for particular applications.

FORWARD-WAVE HELIX TYPE AMPLIFIER

Among the simplest circuit elements which satisfy the broadband low-impedance circuit requirement of the traveling-wave tube is a simple helical transmission line. On this so-called helix, the radio frequency energy essentially travels at the velocity of light along the wire from which the helix is wound. Since the wire and the energy follow this helical path, progress of the energy along the axis of the helix is at some fraction of the velocity of light. This velocity is determined by the geometry of the helix (i.e., circumference and pitch) and by the dielectric loading due to the structure which supports the helix. The fields associated with this "slow-wave" extend outward and inward into the region adjacent to the helix, and it is into this region that electrons are sent to interact with the waves.

If electrons are directed along the axis of the helix at essentially the same velocity as the waves, an interaction between the waves and electrons occurs wherein the electrons become bunched. As the electrons progress along the axis they become packed into tighter and tighter bunches. Simultaneously, the radio frequency fields on the helix increase in magnitude as they progress down its length. The increase in energy of this "growing wave" is just balanced by a decrease in the average kinetic energy of the electrons in the beam. In other words, the electrons, on the average, have been slowed down and have given up just enough energy to account for the increasing energy or power level in the waves on the helix.

In practice, the electron beam is formed by an electron gun and focused down the center of the helix to a collector electrode at the farther end (see Figure 1). The electron beam is maintained in a tight pencil beam throughout the length of the tube by the confining forces of a longitudinal magnetic field which surrounds the tube. Electron velocity is determined by the voltage difference between the cathode in the electron gun and the helix, and this voltage difference is ad-

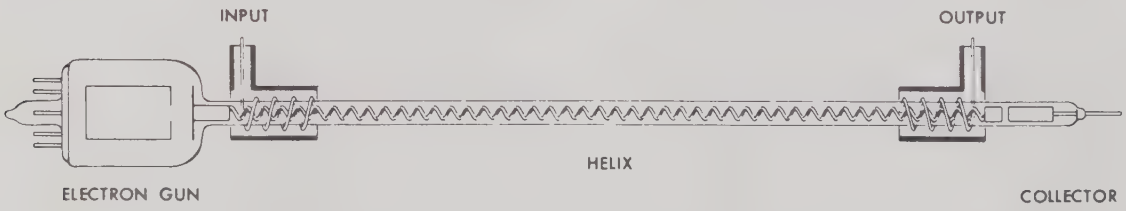


Figure 1. Schematic View of a Traveling-Wave Tube.

justed to give the electrons the right velocity for interaction with the waves. The signal to be amplified is coupled onto the end of the helix nearest the electron gun and propagates along the helix in the same direction as the electron beam. Because of the interaction, the fields on the helix grow exponentially with distance, and these amplified waves are coupled off the helix at the end farthest from the electron gun.

The devices which couple the energy onto and off the helix are special directional couplers which are in themselves helices. These helices are outside the vacuum envelope and are matched to the input and output coaxial transmission lines. This type of coupler is capable of transferring most of the energy from the lines to the main helix, which is inside the vacuum envelope, without making physical contact with the helix. These "coupled helix matches" have the additional advantage of having very wideband transfer characteristic. Further, they are capable of presenting a standing-wave ratio to the coaxial transmission line of 1.5:1 or less.

SPECIFIC CHARACTERISTICS

In the following sections, various characteristic curves that are encountered in traveling-wave tube operation are discussed.

Helix Voltage vs Frequency. A helix is usually designed so that the "slow-waves" travel at a velocity in the range of 1/10 to 1/30 of the velocity of light. If the wave velocity is examined as a function of frequency, it is found that a helix has a general characteristic curve similar to that shown in Figure 2.

In region A, wave velocity varies as a function of frequency; in region B, wave velocity is essentially independent of frequency. A broadband amplifier is normally operated in region B – the "non-dispersive region."

As mentioned before, the electrons must travel at essentially the same velocity as the waves (synchronous velocity) in order to obtain the growing wave interaction. Since the velocity of the wave varies as a function of frequency, the velocity of the electrons must also be varied so that interaction is maintained. Inasmuch as the velocity of the electrons is determined by the voltage difference between the cathode and the helix, there is also a characteristic curve of synchronous helix voltage as a function of frequency (see Figure 2).

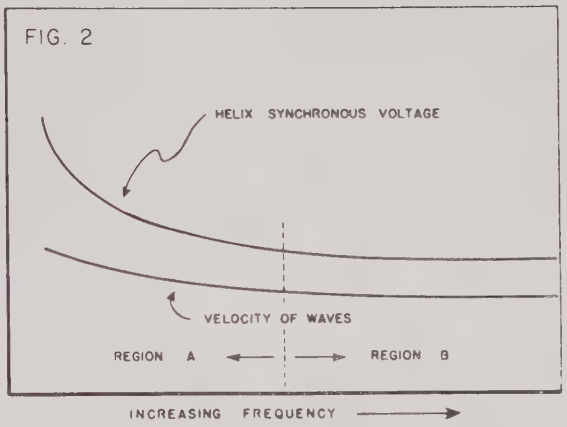


Figure 2. Phase Velocity of the Waves and Synchronous Helix Voltage as a Function of Frequency.

The reason a helix type traveling-wave tube can amplify over wide bandwidths without changing helix voltage can now be easily seen. In the non-dispersive region the synchronous voltage is essentially independent of frequency. That is, the helix voltage which gives the desired interaction between the waves and electrons can be fixed at one value, and this will be the correct value to provide interaction and amplification over a wide range of frequencies.

Gain vs Helix Voltage. To obtain the greatest interaction between the waves and the electrons, and thus the greatest amplification, the helix must be operated at synchronous voltage.

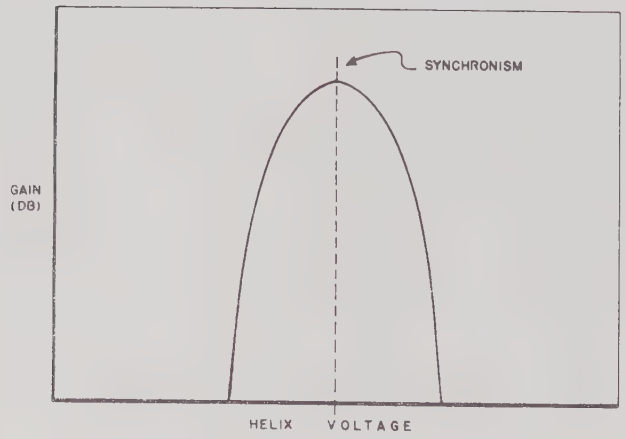


Figure 3. Gain as a Function of Helix Voltage.

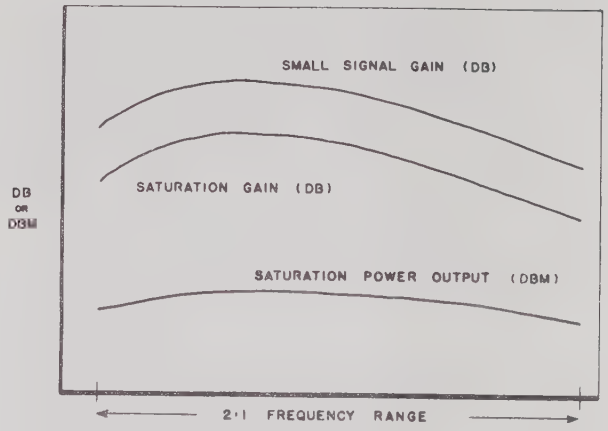


Figure 4. Gain and Power Output as a Function of Frequency.

Should the helix voltage be varied away from synchronism, the gain will decrease as shown by the curve in Figure 3. This characteristic of the TWT is parabolic in shape.

Gain and Power Output vs Frequency. Figure 4 shows a typical plot of gain vs frequency for a fixed value of helix voltage. Small-signal gain is obtained for all values of input signal level except those which drive the tube near its maximum or saturation power output. Saturation gain is the gain obtained when the tube is driven to its saturation power output level. It is seen that the gain and power output curves generally reach a maximum near the center of the band and droop off toward the band edges.

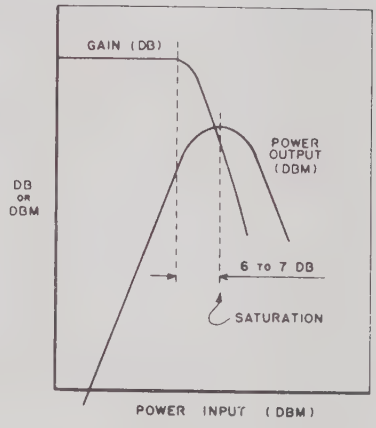


Figure 5. Gain and Power Output vs Power Input at a Fixed Frequency.

Power Output and Gain vs Power Input. Figure 5 shows the variation of power output and gain as a function of power input at a fixed frequency. The amplifier is linear until the power input is within 6 to 7 db of the value which drives the amplifier to saturation. At this point the power output curve begins to droop over, and gain of the tube begins to decrease. At saturation the power output is a maximum, and gain has decreased to the saturation gain level. As the tube is driven beyond saturation the power output drops off, and gain continues to decrease. To obtain maximum power output from an ordinary traveling-wave tube, the right amount of power input must be applied. As will be noted, the saturation region does not exhibit the leveling off or flat saturation characteristic that is found in conventional low frequency amplifier tubes.

Gain vs Beam Current and Grid Voltage. Figure 6 shows that the gain at any fixed frequency is essentially a function of the 1/3 power

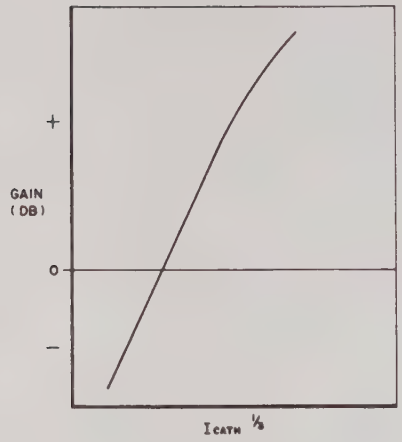


Figure 6. Gain vs Beam Current.

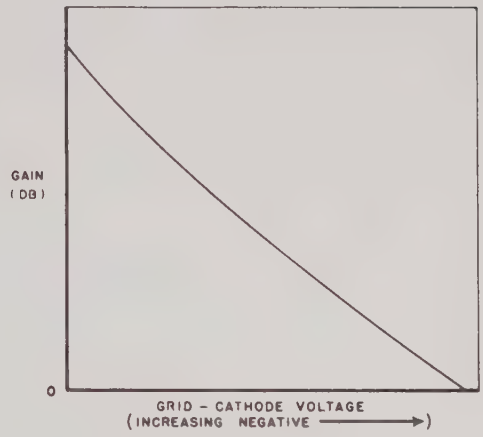


Figure 7. Gain vs Grid Voltage.

of the beam current, and as beam current decreases, gain decreases. Figure 7 shows that the gain of the tube decreases as the grid electrode is made negative with respect to the cathode. This results from the fact that operating the grid negative with respect to the cathode causes the beam current to decrease.

Should the beam current be decreased below a certain value as shown in Figure 6, the gain of the tube measured in db becomes negative, (i.e., the tube is acting as an attenuator). If the beam current is reduced to zero, the net "cold" attenuation of the tube is available. The total change in signal output level as beam current is decreased from its normal value to zero is equal to the sum of the net gain of the tube plus the cold attenuation. This can approach a variation in signal level of about 100 db. Such a change in signal output level is accomplished merely by varying the control grid voltage.

SPECIAL CHARACTERISTICS

Low Noise Amplifiers. A typical low power amplifier may exhibit a noise figure of 20 db. Certain applications require lower noise figures than this. Techniques are available in electron gun design whereby the "shot noise" in the beam can be "de-amplified" before it reaches the beginning of the helix. Special purpose tubes built in this fashion have reached noise figures as low as 6 db.

Narrow Band Amplifiers. Where an application does not require extremely wide bandwidths, tubes can be designed to operate in the dispersive region of the tube characteristic where the velocity of the waves varies as a function of frequency (see Figure 2). In this region, operation at a fixed voltage leads to amplification over only a relatively narrow band of frequencies. Extremely high values of gain (e.g., 60 to 70 db) can be obtained because the problem of controlling spurious oscillations is much simplified since the tube exhibits gain over only a relatively narrow band.

Special Gain Variation. Sometimes special requirements are imposed on the gain variation of the tube as a function of frequency. Tubes can be designed which exhibit an essentially constant value of gain across the band. Others have been built which have linearly increasing gain with frequency. Various other combinations are also possible.

MICROWAVE MEASUREMENT TECHNIQUES†

L. A. Roberts *

As traveling-wave tubes come into more common use, the need becomes apparent for clarification of the various measurement techniques involved in evaluating tube characteristics. In such measurements emphasis must be placed upon broad-band, untuned measuring techniques and test equipment since the traveling-wave tube is a very broadband device. Otherwise, much time would be lost in the repetitive and laborious adjustment and tuning of narrow band devices to make point-by-point measurements across wide frequency ranges.

In this Engineering Note we will concern ourselves with the measurement of small-signal gain, power output, standing-wave ratio, insertion loss, and noise figure. Though automatic and more modern techniques may be available, the methods discussed herein will prove both useful and reliable. Further, these methods require commonly available and relatively inexpensive test equipment.

The types of broadband test equipment commonly used are:

1. Self-tracking tunable signal generator with calibrated power output.
2. Untuned coaxial crystal detector.
3. Untuned coaxial bolometer or thermistor mount with self-balancing power bridge.
4. Broadband coaxial fixed attentuator.
5. Coaxial switch (SPDT).
6. Coaxial slotted section (for VSWR measurements) with untuned detector.
7. Coaxial or waveguide directional coupler.
8. Flourescent noise source.

The emphasis on measuring equipment is placed upon coaxial systems. This is because coaxial test equipment has inherently wideband properties. Waveguide equipment is utilized only when equivalent coaxial equipment is not available or will not do an equivalent job.

SMALL-SIGNAL GAIN MEASUREMENT

A rapid and satisfactory method of measuring gain is to make an insertion gain measurement using the substitution method. This method requires no knowledge of the detector characteristics, nor is absolute power calibration of the signal generator necessary. Accuracy of the measurement depends only on the calibration accuracy of the signal generator output attenuator.

Figure 1 shows a block diagram of the small-signal gain measurement system. With the coaxial switches in position 1, the output of the sig-

* Formerly of Huggins Laboratories, Inc.

† For a detailed discussion of the latest swept-frequency measurement techniques using the Alfred Electronics Model 8000/7051 Sweep Network Analyzer for direct db or dbm readout over a 60-db dynamic range, refer to Alfred Electronics Application Note 101.

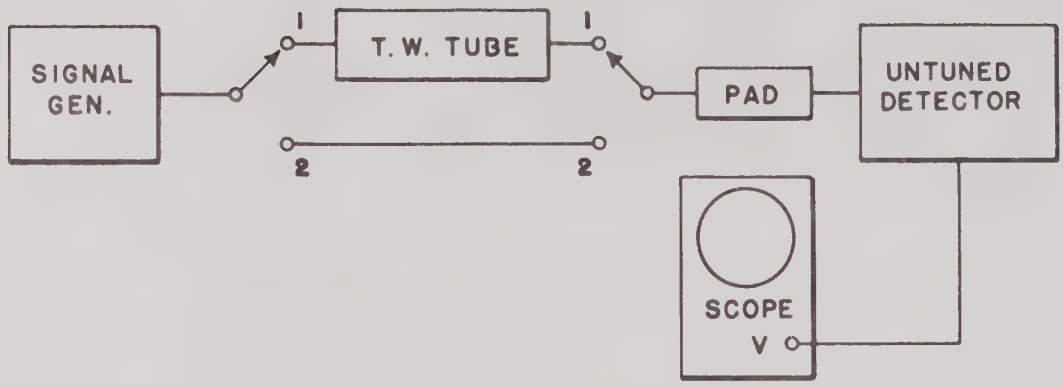


Figure 1. Block Diagram of Gain Measurement System.

nal generator (which has a matched 50 ohm output) is fed to the TWT input through a coaxial single-pole double-throw switch. The output of the TWT is in turn fed through another coaxial switch and a 6 db minimum coaxial fixed attenuator to the untuned detector (If the detector is matched to the coaxial switch, the pad can be eliminated). The detector output is then applied to the vertical deflection channel of an oscilloscope. When the switches are placed in position 2, the tube is by-passed.

Procedure. Apply pulse or square wave modulation to the signal generator. With the tube operating and the switches in position 1, the output attenuator of the signal generator is adjusted to give some convenient deflection on the scope. This is attenuator reading 1. The switches are then placed in position 2 and the attenuator readjusted to give the same deflection on the scope. This is attenuator reading 2. The insertion gain of the tube is then the difference between attenuator readings 1 and 2 measured in db.

Precautions. Both the signal generator and the detector must present good impedance matches as seen by the switch. If they are not matched, reflection losses can give up to several db error in gain. This is the reason for the pad ahead of the unmatched detector, for a 6 db pad guarantees a VSWR of at most 1.5:1.

Also, the switches used must have a low VSWR and very low crosstalk. Crosstalk is stray feedthrough from the input to output terminals of the DPST switch combination through the unused channel. The crosstalk ratio is measured with the TWT removed and is equal to the difference between the signal generator attenuator readings when it is adjusted for equal scope deflection with the switches in position 1 and 2. Regenerative feedback around the switches, which introduces errors in the gain measurement, will be prevented if the crosstalk ratio is at least 20 db greater than the gain of the tube being measured. If the crosstalk ratio exceeds 45 db, it probably cannot be measured with the system in Figure 1. The crosstalk ratio can be measured in such cases with the insertion loss measurement system soon to be described.

Further, care must be taken to insure that the output power level of the tube is at least 10 db below the saturation power level. This eliminates errors due to the decreasing gain characteristic of the traveling-wave tube in the region near saturation.

POWER OUTPUT MEASUREMENT

When making power measurements over wide frequency ranges, it is convenient to use broad-

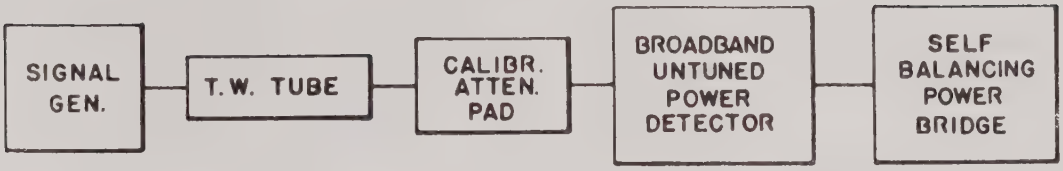


Figure 2. Block Diagram of Power Measuring System.

band (untuned) bolometer or thermistor mounts as power detectors. When these mounts are operated in conjunction with a self-balancing wattmeter bridge, they provide a convenient system for the measurement of absolute power.

If the power level to be measured is greater than the maximum allowable power input to the mount, a calibrated attenuator pad should be inserted ahead of the mount. The most convenient type of pad to use is the resistive film type which has attenuation characteristics that are essentially independent of frequency. Care must be taken not to exceed the maximum input rating of the attenuator.

If power levels to be measured are greater than the rated dissipation of standard attenuator pads, a directional coupler must be placed on the output of the tube. The main arm of the coupler is terminated with a broadband load, and the power detector, with appropriate pads, is placed in the auxiliary arm of the coupler. Broadband coaxial directional couplers with coupling ratios of 10 and 20 db from main arm to auxiliary arm are available.

Should gain measurements be made in conjunction with the power measurements, the power output of the signal generator must be calibrated using its power monitor at each frequency. For accuracy, the power output reading of the signal generator should be initially checked using the bolometer mount and the wattmeter bridge at least over the range of power levels that the bridge can accurately read. Small-signal gain measurements obtained with this equipment should check with the small-signal gain measurements made by the substitution method if the calibration of the attenuator pad and the signal generator is checked.

If all power measurements are recorded in terms of dbm (i.e., db with respect to one milliwatt), the readings of the power bridge, the attenuator (in db) and the signal generator need be merely added and subtracted to obtain power output and gain. Conveniently, most signal generators and power bridges are calibrated in dbm as well as milliwatts.

Figure 2 shows the block diagram of the power measurement system. The power output is given by the equation:

$$\text{Pout (dbm)} = \text{Pad Attenuation (db)} + \text{Ratio of Directional Coupler (db)} + \text{Power Bridge Reading (dbm)}$$

The gain of the tube is given by the equation:

$$\text{Gain (db)} = \text{Pout (dbm)} - \text{Pin from Signal Generator (dbm)}$$

The above gain measurement is valid for both small-signal gain and gain measured in the saturation region and beyond.

STANDING-WAVE RATIO OR REFLECTION COEFFICIENT MEASUREMENT

For direct measurement of voltage standing-wave ratio (VSWR), the coaxial slotted line is the

simplest method. It is essential to have an untuned detector on the slotted line, however, in order to speed up broadband measurements.

When it is necessary to examine the VSWR continuously over a wide frequency range, and where fast checks are required such as on production test setups, the slotted line type of measurement becomes prohibitively time consuming and laborious.

For such situations, the measurement of reflection coefficient through the use of directional couplers is recommended. Two directional couplers which are connected so that one gives an output proportional to the incident wave and the other an output proportional to the reflected wave from the load are used. These two outputs can be detected and compared with a ratiometer to give a direct reading of reflection coefficient. The reflection coefficient is then converted to equivalent VSWR if necessary. The greater the accuracy required in the measurement of reflection coefficient, the higher must be the directivity of the directional couplers. In waveguide, directivity greater than 40 db over the waveguide range can be obtained which allows measurement of reflection coefficient of 0.1 with an accuracy of ±.02. This means that a load VSWR of 1.2 will give an indicated reading between 1.15 and 1.25. A waveguide to coaxial transition can be used to adapt the reflectometer to coaxial systems, but residual reflection in the transition limits the accuracy at low VSWRs.

Once the initial calibration is performed in such a reflectometer system, it is only necessary to tune the signal generator across the frequency range and read the reflection coefficient values directly. An excellent detailed discussion of this method, its errors and limitations, is given in the Hewlett-Packard Journal, Volume 6, Number 1-2, Sept. - Oct., 1954.

Even faster measurements can be made when a swept oscillator is employed. Reflection coefficient can be displayed directly on a scope as a function of frequency, and the measurement can be made at a glance.

INSERTION LOSS MEASUREMENT

Measurement of insertion loss in the range of 40 to 100 db (e.g., cold loss measurement in a traveling-wave tube) over a wide range of frequencies is not uncommon. Such a measurement cannot be made with a 1 milliwatt signal generator and a broadband detector, for this type of system does not have the power levels, nor the sensitivity, to measure much more than 45 db insertion loss.

Wideband measurements can be made quickly and easily, however, with the use of one or two traveling-wave tubes as amplifiers. Use of a traveling-wave tube with a noise figure of 20 db ahead of the detector gives a sensitivity into a broadband detector on the order of –65 to –75 dbm. This alone allows insertion loss measurements of 65 to 75 db. Further, if the output of the signal generator is amplified to the power level of one watt (+ 30 dbm) by using a medium power traveling-wave tube, the total insertion loss then measurable becomes 95 to 105 db.

Since traveling-wave tubes are broadband, untuned devices, the only adjustment necessary in this system as frequency is changed across the band is the tuning of the signal generator. The insertion loss measurement is made in the same manner as the insertion gain measurement shown in Figure 1 except for the addition of the amplifiers before and after the switches. Commercially available switches, when connected as shown in Figure 1, have been measured which have a combined crosstalk ratio in excess of 120 db This, of course, eliminates any crosstalk error in insertion loss measurements in the range of 95 to 105 db.

NOISE FIGURE MEASUREMENT

When one is interested in measuring noise

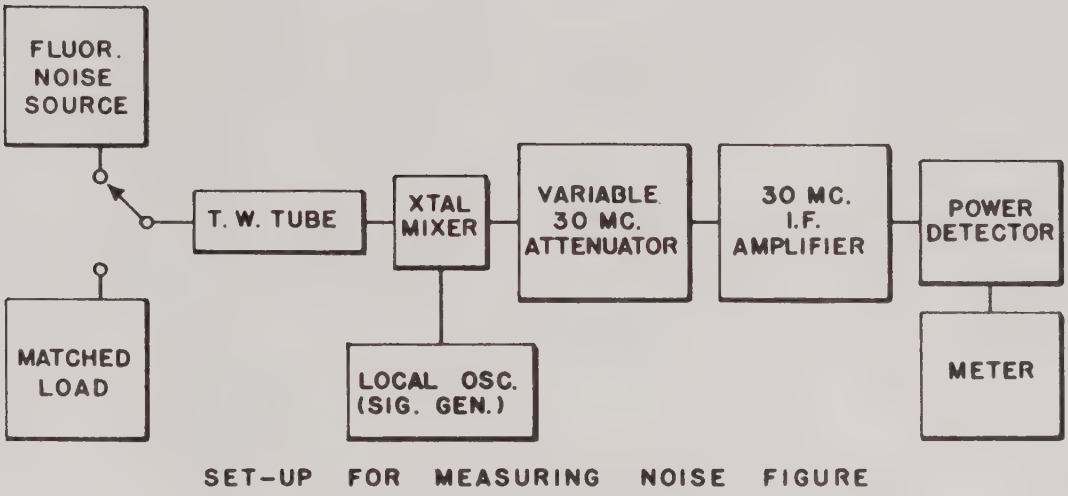


Figure 3. System for Measuring Noise Figure.

figure at a number of frequencies over a wide frequency band, a system which employs a fluorescent tube noise source and a superheterodyne receiver with a square-law second detector (i.e., a power detector) can be used. If noise figure does not vary too rapidly with frequency, a simple receiver can be used which employs an untuned crystal mixer, a local oscillator, a 30 mc IF strip, and a power detector. Note that no preselection or mixer tuning is used.

Without a preselector, the receiver will respond equally well to both the signal and image frequencies. With a 30 mc IF amplifier, these two frequencies will be only 60 mc apart. The measured noise figure will be an average of the true values at two frequencies 60 mc apart providing noise figure is not a rapid function of frequency. This is accurate enough for most purposes. If noise figure varies so rapidly that it will be appreciably different at two frequencies spaced 60 mc apart, then preselection is necessary.

The noise figure of an amplifier is defined as the ratio of the signal-to-noise ratio at the input of the amplifier to the signal-to-noise ratio at the output of the amplifier, That is,

$$F = \frac{(S/N)in}{(S/N)out} \qquad \text{(power ratio)}$$

When the measurement is made according to the method to be outlined, and a noise source whose level is 15.8 db above thermal noise is used, the above equation becomes:

$$F = \frac{37k}{\frac{P_1}{P_2} - 1} \qquad \text{(power ratio)} \qquad (1)$$

where, P_1 and P_2 are as defined in the measurement procedure below, and k, a number smaller than 1.0, is the cable loss in db between the noise source and the tube converted to a power ratio. (e.g.) for cable loss = 1db, k = .794)

When a fluorescent noise source is used, it is not necessary to know the effective RF noise bandwidth of the receiver.

Procedure: The tube to be measured is connected into the system shown in Figure 3. The

power detector in the receiver may take the form of a bolometer or a thermistor operating into a self-balancing wattmeter bridge, or it may be a thermocouple whose output is connected to a microammeter.

With the TWT operating and the local oscillator tuned to the desired frequency, switch the tube input to the noise source. Adjust the variable 30 mc attenuator until the output meter indicates approximately full scale. This is reading P_1.

Then switch the tube input to the matched load. The output meter now indicates P_2. Insert the values of P_1 and P_2 in equation 1 and compute the noise figure. To determine the noise figure in db, merely convert this number to db.

Precautions: The accuracy of this measurement is based on the assumption that the receiver is linear. This will be true if the local oscillator signal is large enough to produce linear mixing and if the IF amplifier is operated in the linear portion of its characteristics

The measurements should be taken quickly enough so that power meter drift will not affect readings.

ALFRED

Tube Warranty and Replacement Procedure

Tube Replacement

All TWT and BWO tubes furnished in ALFRED instruments are available from ALFRED ELECTRONICS or the tube manufacturer for either warranty or out-of-warranty replacements. Current prices are given on the Replacement Tube Price List.

Tube Warranty

On ALFRED supplied BWO, TWT, and VTM tubes used in catalog instruments, ALFRED ELECTRONICS extends the full warranty given by the tube manufacturer and offers the following minimum:

Warranty for Huggins, ITT, & Litton TWT's

Tubes are warranted unconditionally against defects in workmanship, materials, and construction for the period shown in Column A and the number of heater hours shown in Column B. To supplement the unconditional warranty, the tubes are warranted on a pro-rata basis for the rated number of heater hours shown in Column C or for one year, both computed from the date of original shipment by ALFRED, whichever expires first. The pro-rated adjustment will be based on the current list price of the tube and the unused percentage of heater hours (Column C) or one-year time period, whichever results in lesser credit.

Warranty for MEC TWT's and All BWO Tubes

Tubes are warranted unconditionally against defects in workmanship, materials, and construction for the period shown in Column A and the number of heater hours shown in Column B. To supplement the unconditional warranty, the tubes are warranted on a pro-rata basis for the rated number of heater hours shown in Column C or for one year, both computed from the date of original shipment by ALFRED, whichever expires first. The pro-rated adjustment will be based on the current list price of the tube and the unused percentage of heater hours (Column C).

Mfg.	Power	A months	B hours	C hours
		TWT		
Huggins	1 - 10 mw	6	500	2000
MEC	1 - 20 mw	6	1000	2000
Huggins	1 watt	6	250	1000
MEC	1 - 10 watt	6	500	1000
Huggins	low noise to 15 db	6	500	2000
MEC	low noise to 15 db	6	1000	2000
ITT	10 watt	2	50	500
Litton	10 watt	6	50	500
		BWO		
All	0.5 - 40 GHz	6	200	2500
		VTM		
Eimac	0.25 - 1 GHz	6	100	1000

WARRANTY CONDITIONS APPLY ONLY TO TUBES LISTED ABOVE WHICH ARE USED IN ALFRED CATALOG INSTRUMENTS.

Return Authorization

TO OBTAIN WARRANTY CREDIT THE TUBE SERVICE REPORT MUST BE COMPLETED AND RETURNED WITH THE TUBE.

Return Procedure

In case a tube or instrument fails, please contact the factory or your local sales representative for advice or authorization to return either the tube or the instrument to the factory. NO TUBE OR INSTRUMENT WILL BE ACCEPTED FOR REPAIR OR CREDIT ADJUSTMENT WITHOUT WRITTEN AUTHORIZATION AND ACCOMPANYING SERVICE REPORT.

When the authorization is received, pack the tube in a rigid container (use original carton if available) at least 4" larger than the tube in each dimension. Wrap the tube with 1/4" of soft padding material and heavy kraft paper before placing in container. Pack at least 2" of resilient dunnage such as rubberized hair, foam, or similar shock absorbing material completely around the tube. Mark the container "FRAGILE" and ship PREPAID via air freight, air express or rail express. Do not ship via parcel post or air parcel post since experience has shown that fragile items are more apt to be damaged when shipped via these methods.

Use similar wrapping, packing and shipping provisions for an instrument. At least 6" of rubberized hair (or equivalent shock absorbing material) is required for an instrument.

In-Warranty Failure - BWO and VTM Tubes

BWO and VTM tubes which fail in warranty will be replaced with a new tube. In case a tube fails, please issue a purchase order for a new tube at the tube list price and return the defective tube. Warranty credit will be issued and deducted from the price, subject to tube manufacturer's verification that failure was caused by tube malfunction. To qualify for maximum credit, it is essential that the defective tube be properly packed and promptly returned.

Repairable or In-Warranty Failure - TW Tubes

If the returned tube is found to be repairable, the user will be asked to issue a purchase order for repair charges determined by the original tube manufacturer. In general, the repair will be at no cost if the tube is in warranty and there is no evidence of misuse or abnormal conditions of operation.

Warranty Credit

Any applicable credit allowed under the terms of this warranty applies only toward the future purchase of a replacement tube from ALFRED ELECTRONICS. Cash settlements will not be made. In terms of this warranty, a replacement tube must be the same type as that on which credit is allowed. Credit for one tube only may be applied toward the purchase of a single replacement tube. Warranty credit remains in effect for a maximum of six (6) months from date ALFRED ELECTRONICS notifies the customer. All credits will be based on the purchase price of the tube which prevails at the time the order for a replacement tube is received by ALFRED ELECTRONICS.

BWO RF Cables

RF OUTPUT CABLE MUST ACCOMPANY BWO TUBES returned for warranty credit, repair or replacement. If rf output cable is NOT returned, the cable price is added to the normal BWO repair or replacement charge. For prices see Replacement Tube Price List.

Special Conditions

If a returned tube or instrument proves not to be defective after test and evaluation at ALFRED ELECTRONICS, the tube or instrument will be returned at the customer's expense.

The final determination as to whether the tube failed in normal operation thereby bringing it under the applicable warranty or whether the tube was misused thereby excluding it from application of the warranty provisions, lies solely with the tube manufacturer.

Data, warranty credit, and prices subject to change without notice.

4/6/67

ALFRED ELECTRONICS

Service Report

Instrument Model _____ Serial No. _____ Date Received _____

TW/BWO Tube Type _____ Serial No. _____ Date Received _____

Date First Tested _____ Date Placed in Service _____ Date of Failure _____

Total Number of Hours of TWT/BWO Heater Operation _____

_____

1. Was operation normal just prior to failure? Yes _____ No _____

2. If not, what was done to adjust it? _____

_____

_____

3. Has proper cooling been maintained during tube operation? _____

_____

4. Did helix overcurrent tripout occur? _____

_____

5. Was environment normal? (specify) _____

_____

6. Symptoms - (describe failure) _____

_____

_____

7. Operating conditions at time of failure (indicate any unusual conditions) _____

_____

_____

8. Name of person to contact regarding evaluation of failure _____

Telephone No. _____ Signature _____

Title _____

Date _____

ALFRED

Tube Warranty and Replacement Procedure

Tube Replacement

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Return Authorization

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In case a tube or instrument fails, please contact the factory or your local sales representative for advice or authorization to return either the tube or the instrument to the factory. NO TUBE OR INSTRUMENT WILL BE ACCEPTED FOR REPAIR OR CREDIT ADJUSTMENT WITHOUT WRITTEN AUTHORIZATION AND ACCOMPANYING SERVICE REPORT.

When the authorization is received, pack the tube in a rigid container (use original carton if available) at least 4" larger than the tube in each dimension. Wrap the tube with 1/4" of soft padding material and heavy kraft paper before placing in container. Pack at least 2" of resilient dunnage such as rubberized hair, foam, or similar shock absorbing material completely around the tube. Mark the container "FRAGILE" and ship PREPAID via air freight, air express or rail express. Do not ship via parcel post or air parcel post since experience has shown that fragile items are more apt to be damaged when shipped via these methods.

Use similar wrapping, packing and shipping provisions for an instrument. At least 6" of rubberized hair (or equivalent shock absorbing material) is required for an instrument.

In-Warranty Failure - BWO and VTM Tubes

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Warranty Credit

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Special Conditions

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The final determination as to whether the tube failed in normal operation thereby bringing it under the applicable warranty or whether the tube was misused thereby excluding it from application of the warranty provisions, lies solely with the tube manufacturer.

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4/6/67

ALFRED ELECTRONICS

Service Report

Instrument Model _____ Serial No. _____ Date Received _____

TW/BWO Tube Type _____ Serial No. _____ Date Received _____

Date First Tested _____ Date Placed in Service _____ Date of Failure _____

Total Number of Hours of TWT/BWO Heater Operation _____

_____

1. Was operation normal just prior to failure? Yes _____ No _____
2. If not, what was done to adjust it? _____

   _____

   _____
3. Has proper cooling been maintained during tube operation? _____

   _____
4. Did helix overcurrent tripout occur? _____

   _____
5. Was environment normal? (specify) _____

   _____
6. Symptoms – (describe failure) _____

   _____

   _____
7. Operating conditions at time of failure (indicate any unusual conditions) _____

   _____

   _____
8. Name of person to contact regarding evaluation of failure _____

   Telephone No. _____ Signature _____

   Title _____

   Date _____

SHIPMENT DAMAGE CLAIM

The instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim must be filed with the carrier. Have carrier agent inspect damage to instrument and packing crate and forward us a copy of his written report. You will then be advised of replacement or repair arrangements and disposition of the equipment. Please include model number, type number and serial number when referring to this instrument for any reason.

WARRANTY

ALFRED products are warranted against defects in workmanship and materials. This warranty is limited to repair or replacement of products or parts (except tubes, transistors, and batteries) which prove defective within one year after delivery to original purchaser. ALFRED ELECTRONICS is not liable for consequential damage.

If any fault develops:

1. Notify us, giving full details of the difficulty, including the model number, type number and serial number. Upon receipt of this information, you will be sent service instructions or shipping data.

2. Upon receipt of shipping instructions, forward the instrument prepaid and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins when instrument is not covered by this warranty.

PACKING

The instrument should be packed in the original carton. If unusable or not available, use a wooden box with approximately three inches of excelsior or other shock-absorbing material surrounding the instrument. If desired, packing services of a local transfer and storage company may be employed.

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